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And Auxiliary Machinery as supplied to the Admiralty. 2179

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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS } Row's Patents.
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See Advertisement, page 27. 1872

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Large quantity of CAST IRON FLANGED PIPING, 4 in. to 12 in. diameter, principally in 9 ft. lengths.

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LOCO TYPE BOILER, barrel 4 ft. 7 in. long by 3 ft. diameter, reinsure 80 lbs. pressure.

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Nearly New 100 tons HYDRAULIC PRESS, 16 in. ram, about 3 ft. stroke, working pressure 1500 lbs., by J. Shaw & Sons.

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One Superior 400 Kw. Howden-Siemens ELECTRIC GENERATING SET, 250 volts D.C., 350 r.p.m., 155 lbs. pressure.
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In new condition and all seen here at Glasgow.
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STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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See Advertisement page 64, June 27. 2402

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works and Showrooms: BIRMINGHAM. See Advert., page 96, June 20. 3195

Railway Switches and Crossings.
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We are organised to produce castings from 2 lbs. to 2 tons. Cast-iron, Semi-steel, and Non-ferrous castings. Coils of every description, Steel and Copper. Sheet Metal Work. Over 40 years' experience is at your service. Send your enquiries along.

Diesel Engines, 300, 530, 800,
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SESSION 1924-1925.

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DEAN: Professor T. B. ABELL, O.B.E., M.Eng., R.C.N.C., Ret., M.Inst.N.A.

Prospectus and full particulars of the following may be obtained on application to the REGISTRAR:—Engineering, Thermodynamics of Heat Engines, Strength of Materials, Electrical Engineering, Civil Engineering, Naval Architecture, Marine Engineering, Metallurgy, Geology, Design and Drawing, Refrigeration, Mathematics, Physics, Chemistry. D 415

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A prospectus of the Faculty, giving particulars of courses and a large number of Entrance and Post-graduate Scholarships, may be had on application to the undersigned.

EDWARD CAREY,
Registrar. D 348

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TENDERS.

For Sale.—Two 50 Cwt.

Hydraulic Portal Pier COAL UNLOADING CRANES (reconditioned), 38 ft. radius, Luffing Jibs, slewing and (hoisting motions, mounted on pedestal base with 4 wheels running on track, 11 ft. 6 ins. centres, spanning wagon road 4 ft. 8½ ins. gauge. These may be inspected by appointment on application to THE CHIEF OFFICER OF STORES, Gas Light and Coke Company, Horseferry Road, Westminster, S.W.1, to whom all Tenders should be addressed. F 149

LODGE HILL, near CHATHAM.

Tenders are Invited for

the PURCHASE and REMOVAL of the undermentioned TIMBER FRAMED HUTS, now at Chattenden Farm, Lodge Hill, and of approximate floor measurements as follows:

2 No. 60 ft. by 20 ft.
1 No. 60 ft. by 39 ft.

Tenders are to be delivered not later than Noon on July 11th, 1924, to SUPERINTENDING CIVIL ENGINEER, H.M. Dockyard, Chatham, from whom full Particulars and Forms of Tender may be obtained. F 128

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 16th July,

Tenders for the Supply of:—

1.—SCREW COUPLINGS.
2.—PLATE AND SHEET GLASS, ETC.
3.—TYRES FOR CARRIAGES AND WAGONS.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France, Westminster, S.W.1. F 217

BENGAL-NAGPUR RAILWAY COMPANY LIMITED,

The Directors are prepared to receive

Tenders for:—

1—40 TON STEAM WRECKING CRANE.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 30th June, 1924.

A fee of 20/- will be charged for the specification, which is NOT returnable.

Tenders must be submitted not later than Noon on Thursday, 10th July, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKER,
Secretary, F 188

METROPOLITAN BOROUGH OF ST. PANCRAS.

WATER TUBE BOILERS AND PULVERISED FUEL PLANT.

The Electricity Committee invite

Tenders for the Supply and

ERECTION of TWO WATER TUBE BOILERS of 40,000 lbs. each, complete with pulverised fuel plant.

Specifications and Drawings may be obtained at the Offices of the department, 57, Pratt Street, Camden Town, N.W., on the payment of £2, which will be returned on the receipt of a *bona fide* Tender.

The Council are not bound to accept the lowest or any Tender.

Tenders to be sent in to the undersigned on or before Tuesday, July 15th, 1924.

C. H. F. BARRETT,
Town Clerk.

Town Hall,
Pancras Road, N.W. 1. F 183

COUNTY OF LONDON.

BELL WHARF OUTLET, SHADWELL.

The London County Council invites

Tenders for the Construction

of a 4 ft. diameter SEWER in Brick and Concrete of a total length of about 200 feet, with Wier Chamber and Tumbling Bay, in the Metropolitan Borough of Stepney, in the Administrative County of London.

Persons desiring to submit Tenders may obtain the Drawing, Specification, Form of Tender, etc., on application, on or after Monday, 7th July, to the Chief Engineer at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £5, by charge or draft to the order of the London County Council. This amount shall be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained upon personal application, and the contract documents may be inspected at the Old County Hall before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after Four p.m. on Monday, 28th July, 1924, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, F 206
Clerk of the London County Council.

IN THE HIGH COURT OF JUSTICE (Companies Winding Up).

To be Offered For Sale by

TENDER, pursuant to a Order of the Registrar Companies (Winding Up) made in the matter of ALLEN & SIMMONDS (READING), LTD., Branch Nominees Ltd., v. Allen & Simmonds (Reading), Ltd., 1923, A. No. 2686, either in One Lot as a Going Concern, or in the following Lots:—

LOT 1.

(A) A FREEHOLD GARAGE, SHOWROOMS AND OFFICES situate in the centre of READING, with frontages to Friar Street and Station Road, and containing an area of about 33,000 square feet, together with the Assets and the Business carried on on such premises, and the whole of the Share Capital and Debentures in Great Western Motors Ltd.

(B) A block of TEN FREEHOLD COTTAGES adjoining the above.

(C) A FREEHOLD FACTORY at Vastern Road, READING, with Modern Buildings thereon, covering an area of about 14,500 square feet, at present let as a Motor Body Building Works, in connection with the aforesaid business.

LOT 2.

(A) A LEASEHOLD ENGINEERING WORKS, at READING containing a total floor space of about, 27,000 square feet, held for an unexpired term of 67 years at Ground Rents amounting to £77 6s. per annum. These Works are equipped with high-class ENGINEERS' MACHINE TOOLS for the manufacture of Piston Rings and other Specialities of the Company.

(B) THIRTY LEASEHOLD COTTAGES and a RESIDENCE adjoining held for a similar period at nominal ground rents.

(C) LEASEHOLD PREMISES suitable for GARAGES, situate No. 107, Caversham Road, READING, held for an unexpired term of 61 years.

(D) A FREEHOLD PROPERTY on the THAMES, at CAVERSHAM, adjoining the Bridge, formerly a Club, but now let off in self-contained Flats.

(E) A FREEHOLD HOUSE, No. 18, King's Meadow Road, READING.

(F) THE GOODWILL OF THE BUSINESS of ALLEN & SIMMONDS (READING), LTD., as a Going Concern, and LETTERS PATENT for Improvements in the manufacture of Piston Rings, etc.

LOT 3.

3,000 £1 fully-paid Shares, Great Western Hotel (Reading), Ltd.

25 £1 fully-paid Deferred Ordinary Shares, and 5,500 £1 fully-paid Participating Preferred Ordinary Shares in the Reading Foundry Co., Ltd.

Tenders, which must be on the form contained in the Particulars, are to be sent to the Registrar, Companies (Winding Up), Room 48, Bankruptcy Buildings, Carey Street, W.C.1, and marked "Tender re Allen & Simmonds (Reading), Ltd.," and delivered under seal by TWELVE NOON, on or before SATURDAY, 19th July, 1924. Particulars, with Plan, Form of Tender and Conditions of Sale, may be had of Messrs. W. B. PEAT & CO., Chartered Accountants, 11, Ironmonger Lane, London, E.C.2, Messrs. WILDE, WIGSTON & SAPTE, Solicitors, 21, College Hill, London, E.C.4; and of Messrs. PEACOCK & GODDARD, of 3, South Square, Gray's Inn, London, W.C.1 F 39

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for:—

1. FENCING, WIRE STRAND..... Fee 10/-

Tenders are due by Eleven a.m. on 15th July, 1924. Tender forms obtainable at above address. Fee not returnable. F 242

85 FEET SPAN GIRDER BRIDGE.

Tenders are Invited for

the IRONWORK only of the above dismantled bridge. Approximate weight 52 tons 15 cwts. The bridge and specifications can be seen at SCHOOL OF MILITARY ENGINEERING, Chatham. Tender forms can also be obtained therefrom. F 218

TYNE IMPROVEMENT COMMISSION.

ELECTRIC MOTORS AND ACCESSORIES.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Supply and

delivery of one 20 HP., and three 3 HP. D.C. ELECTRIC MOTORS, for their Albert Edward Dock, Percy Main, North Shields.

Copies of the Form of Tender and Specification may be obtained on application to the undersigned.

Tenders in sealed envelopes, endorsed on the cover "Tender for Electric Motors and Accessories," must be delivered at the undermentioned Offices addressed to "The Chairman of the Docks Committee, Tyne Improvement Commission," not later than Noon, on Saturday, the 12th day of July, 1924.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
27th June, 1924. F 187

METROPOLITAN ASYLUMS BOARD.

TO ELECTRICAL ENGINEERS.

The Board invite separate

Tenders for

(A) The INSTALLATION OF ELECTRIC LIGHTING and POWER MAINS, SUB-MAINS, MAIN SWITCHES, FUSEBOARDS, etc., etc., at the Office of the Board, Victoria Embankment, E.C.4.

(B) The INSTALLATION of an INTERNAL TELEPHONE SYSTEM in the Accountant's Dept., at the Office of the Board, Victoria Embankment, E.C.4.

(C) The INSTALLATION of an INTERNAL TELEPHONE SYSTEM in the Engineer-in-Chief's Dept., at Sheffield House, Sheffield Street, W.C.2.

in accordance with the Specifications and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specifications, Drawings, and Forms of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m. on Wednesday, the 2nd July, 1924, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the Instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders addressed as noted on the Form must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, the 16th July, 1924.

(By Order) G. A. POWELL,
Clerk to the Board. F 205

METROPOLITAN WATER BOARD.

DISPOSAL OF WROUGHT IRON BOILERS (OLD AND DISUSED).

The Metropolitan Water Board invite

Tenders for the Purchase and

Removal of six old disused Cornish Boilers, situate at their works at Lea Bridge, Clapton.

These Boilers may be seen at the above-mentioned works at any time between 9 a.m. and 4 p.m. on week days (Saturdays excepted) on application to the Engineer-in-Charge.

Forms of tender and conditions of contract may be obtained on and after 3rd July, 1924, from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, by personal application (Room 155), or upon forwarding a stamped addressed envelope.

Tenders must be on the official forms, enclosed in sealed envelopes, addressed to the Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, endorsed "Tender for Boilers, Lea Bridge," and delivered at the Offices of the Board not later than Eleven a.m. on Monday, 14th July, 1924.

The Board do not bind themselves to accept the highest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C.1.
30th June, 1924. F 237

APPOINTMENTS OPEN.

Assistants with Tech-

nical training to the standard of B.Sc. degree and works and drawing office experience, are REQUIRED at the Royal Aircraft Establishment, South Farnborough, Hants.

A-30.—For the Airworthiness Department, in connection with checking by calculation the strength and aerodynamic characteristics of aeroplanes. One with special proficiency in mathematics is required and one with a good knowledge of technical French.

A-31.—For the Mechanical Testing Department, for tests and experimental work on strength of materials and aircraft components.

Starting salary about 60s. per week, plus Civil Service Bonus, giving present total of 97s. per week. Ex-service men preferred.

Apply, quoting the above reference numbers, to SUPERINTENDENT, R.A.E., South Farnborough, Hants. F 215

NORTHAMPTON POLYTECHNIC INSTITUTE, Clerkenwell, London, E.C.1.

The Governing Body invite

Applications for the Appoint-

MENT of PRINCIPAL of the Northampton Polytechnic Institute, from University Graduates, or persons of equivalent standing, familiar with the training of engineers. In addition to Mechanical, Civil, Electrical and Optical Engineering (with a four-year day course of University Grade), the curriculum includes Technical Chemistry, Horology and Women's Subjects. There is a social side, with recreation ground, swimming bath, gymnasium, choir, orchestra, etc. The Principal will be the responsible Head and must be experienced in administrative organization.

The initial salary sanctioned by the Education Authority is £1,250, and, in common with all teachers' salaries on the Burnham Scale, is subject to an abatement at present of 5 per cent. and to deductions under the School Teachers (Superannuation, Acts.

Particulars of the duties and conditions of the appointment may be obtained by writing to the undersigned, to whom applications on special forms must be returned not later than July 12th.

It is desirable that the selected candidate should take up his duties early in September, 1924. F 213

W. K. DAVIS, Clerk to the Governing Body.

COUNTY BOROUGH OF WOLVERHAMPTON.

DEPUTY WATER ENGINEER.

The Council are prepared to receive

Applications from Qualified

Engineers for the above position, for which a salary and bonus of £400 per annum will be paid, advancing by two annual increments of £25, subject to satisfactory service.

The Council having adopted the Local Government and other Officers' Superannuation Act, 1923, the appointment will be subject to percentage deductions in accordance with the provisions of the Act.

Applications, stating age, experience, qualifications and present salary, together with copies of three recent testimonials, must be delivered to my office before Noon on Friday, the 18th inst.

Canvassing members of the Council personally or otherwise will disqualify Applicants.

(Sgd.) E. A. B. WOODWARD,
Water Engineer and Manager.

Town Hall,
Wolverhampton.
2nd July, 1924. F 250

Assistant Works

MANAGER WANTED in Established Engineering Works, Midland District, manufacturing Steam, Oil and Gas Engines, also Pumps. 2000 employees. This is a really good opening with plenty of scope for a sound practical progressive man of strong character and ability. A knowledge of modern workshop methods and organisation is essential. Age about 35. Write, stating experience, age, and salary required. All applications will be treated in confidence.—Address, F 254, Offices of ENGINEERING.

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prospects for a thoroughly Competent ENGINEER, to act as Assistant in general engineering works. Applicants must have first-class and complete knowledge of draughtsmanship, designing, and estimating, and be thoroughly acquainted with river craft. Knowledge of commercial side of Engineering business desirable. Progressive salary to suitable man.—Address, stating age, whether married or single, and giving full particulars of experience, etc., F 253, Offices of ENGINEERING.

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FOUNDRY & ENGINEERING CO., LTD., HAVE VACANCIES in their various branches for TECHNICAL ASSISTANTS for preparation of schemes and estimates for Heating, H.W.S., Ventilation, &c. Good prospects if satisfactory. Applications treated as confidential. State age, experience and salary required.

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Manager REQUIRED for leading firm of Internal Combustion Engineers. Good connection in Engineering circles desirable. Sound commercial ability and intimate knowledge of mechanical, electrical and marine work necessary. Applications treated as strictly confidential.—Address, F 204, Offices of ENGINEERING.

Required, for the Sales

Department of an Old Established Firm of Engineering Stores, a Qualified ASSISTANT, with engineering knowledge and experience in technical quotations. Must be alert and industrious and capable of following up business.—Address qualifications to F 199, Offices of ENGINEERING.

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ENGINEERING

STRESSES DUE TO A LOADED SURFACE WHEN EARTH IS TREATED AS AN ELASTIC SOLID.

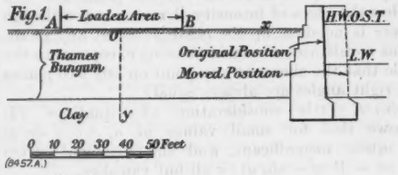
By S. D. Carothers, A.M.Inst.C.E., A.R.C.Sc.(I).

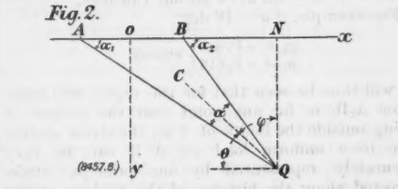
During recent years the question of treating earth as an elastic solid has been brought forward in various quarters as a means of obtaining the stresses in an earth foundation. As usually treated earth problems admit of a variety of solutions, according to the ability and personal opinions of the particular writer dealing with the question. The great advantage of treating earth as an elastic solid lies in the fact that an adequate theory, as applied to elastic solids, is ready to hand which for any given problem, furnishes one, and only one, solution. This does not mean that if earth is treated as an elastic solid the pressure on, say, a retaining wall, would have a fixed value for all varieties of earth. The solution, if obtainable in any given case, would usually involve elastic constants which have different numerical values for each particular earth, and thus the stresses would generally vary in consequence. Up to the present, little or nothing has been done in determining the elastic constants of earth.

When it is considered that over this country there must be hundreds, or perhaps thousands, of daily tests carried out on materials such as steel, the properties of which are exceedingly well known and the manufacture of which is reduced to ordinary routine, it seems curious that the number of recorded tests carried out in a year on earth, the properties of which are practically unknown, should be all but negligible; but such seems to be the case. If the phenomena attending the failure of an admittedly elastic substance, such as steel under tension, are considered, it is found that within certain limits the steel is elastic. Outside the limits referred to, recovery from the effect of stress is incomplete, while at the point just below rupture the steel acts as a plastic substance, at least near the point of failure.

If similar tests are applied to earth in compression, there is every reason to believe that, for many kinds of earth, the same rules would apply, provided earth is subjected to compression only. If the limits between which the various kinds of earth acted as elastic solids were known and the points at which plasticity set in were found, considerable progress would have been made. If the values of the elastic constants are not known, the solution of most elastic problems can only be reduced to arithmetic by taking these at assumed values.

There is, however, a whole class of problems which forms an exception to the above, where the stresses are independent of the elastic constants, and under certain circumstances, which will be referred to later, the results obtained for this class should have a very wide application and might be held to apply to earth foundations without in the least offending common sense. It is not to be assumed that the results should apply equally to all kinds of earth, and this is where common sense and





engineering experience should aid in determining the limits to which one might go.

The class of problem referred to above falls under the heading of plane strain. Such a state of strain would be produced in a semi-infinite solid having a plane upper boundary by the uniform loading of a long narrow strip having parallel edges. A similar state of strain would be produced by pressure varying in any manner across the strip, provided the pressure on any line parallel to the edges of the strip was the same at all points. The stresses produced in such cases by surface loading are independent of the elastic constants.

Examination of the conditions of failure of a retaining wall some time ago revealed the great practical importance of this question. In the case referred to, the ground was loaded with wood pulp to a considerable height along a rectangular strip about 600 ft. long and 50 ft. wide, and the wall, which was parallel to the long edge of the strip, failed by sliding on its base and, in places, leaning back at the top at a considerable angle. The ground on which the wall was founded was clay, but that on which the wood pulp rested was locally known as Thames "bungum," and the surface of the ground was considerably below the top of the wall.

The conditions were approximately as shown in Fig. 1. At the time of inspection of the failure of the wall, it was seen that the ground under the loaded area had gone down and the surface outside the loaded area had risen a few inches, but the movements were not great. In this case, if the earth is considered as an elastic solid, the failure of the wall can be completely accounted for, and, on the other hand, if the earth is not considered as an elastic solid, there is no adequate theory either to calculate the stresses or otherwise estimate their magnitude and direction. With this in mind, it has been considered that a short paper giving the stresses in ground treated as an elastic solid would be of interest and use. The notation used will be that of Love, "Elasticity," second or third edition.

The paper is divided into two parts as follows:—

Part 1. An extended summary giving most of the results in as short a form as possible.

Part 2. An appendix where the proofs will be found, but this appendix is intended to be as free from mathematics as it is possible to have it.

Part I.—Summary.

In the case of a semi-infinite solid having a plane upper boundary carrying a load uniformly spread on a long strip, with parallel edges, there are two distinct sets of stresses which require to be treated. These sets of stresses must be dealt with separately and apart; they are:—

(A) The stresses existing in the foundation due to the weight of the earth itself and apart from any load on the surface.

(B) The stresses in the earth solely due to the load on the surface.

It will obviously be an advantage to select axes of reference equally convenient in respect to either set of stresses.

Take the axis of z as the central line of the loaded strip, the axis of x horizontal and in the surface, and the axis of y vertically downwards through the z axis.

(A) *Stresses in foundation due to weight of the earth.*—In this case, the solution would depend on the past history of the earth foundation. For example, if it is assumed that the foundation was formed by gradual accretion in horizontal layers, it

will be shown that the stresses in the earth at any depth y are as follows :—

$$\left.\begin{aligned} \widehat{xx} &= -\lambda w y/(\lambda+2\mu) \\ \widehat{yy} &= -w y \\ \widehat{zz} &= -\lambda w y/(\lambda+2\mu) \\ \widehat{xy} &= \text{zero} \end{aligned}\right\} \quad . \quad (1)$$

where $\widehat{xx}$ is the pressure normal to the plane x = constant,

$\widehat{yy}$ is the pressure normal to the plane y = constant,

$\widehat{zz}$ is the pressure normal to the plane z = constant,

$\widehat{xy}$ is the shear on either the horizontal or vertical plane at any point,

and λ and μ are the elastic constants of the earth.

(B) *Stresses due to the loaded strip of width* $AB = 2a$.—In Fig. 2 axes are selected as shown

and
$$OA = OB = a$$
$$\text{Angle } AQB = \alpha$$
$$\text{Angle } QAB = \alpha_1$$
$$\text{Angle } QBN = \alpha_2$$

If QC is the bisector of α and is inclined to the horizontal and vertical planes at angles θ and ϕ respectively, and AB carries a uniform load of P units of pressure per unit surface throughout the length of the strip, it will be shown that :—

(a) The stress at any point Q can be expressed in terms of a and y, &c. The stresses are, in fact :—

$$\left.\begin{aligned} \widehat{xx} &= -P\left(\alpha + y\frac{\partial\alpha}{\partial y}\right)/\pi \\ \widehat{yy} &= -P\left(\alpha - y\frac{\partial\alpha}{\partial y}\right)/\pi \\ \widehat{xy} &= -P\left(-y\frac{\partial\alpha}{\partial x}\right)/\pi \end{aligned}\right\} \quad . \quad . \quad (2)$$

(b) The stresses at Q can also be expressed in a variety of ways in terms of the angles α, α_1, α_2, &c. Perhaps the simplest and most symmetrical form is :—

$$\left.\begin{aligned} \widehat{xx} &= -P(2\alpha_2 - 2\alpha_1 + \sin 2\alpha_2 - \sin 2\alpha_1)/2\pi \\ \widehat{yy} &= -P(2\alpha_2 - 2\alpha_1 - \sin 2\alpha_2 + \sin 2\alpha_1)/2\pi \\ \widehat{xy} &= -P(\quad\quad - \cos 2\alpha_2 + \cos 2\alpha_1)/2\pi \end{aligned}\right\} \quad (3)$$

Other forms are :—

$$\left.\begin{aligned} \widehat{xx} &= -P(\alpha - \sin\alpha\cos 2\theta)/\pi \\ \widehat{yy} &= -P(\alpha + \sin\alpha\cos 2\theta)/\pi \\ \widehat{xy} &= -P(\quad - \sin\alpha\sin 2\theta)/\pi \end{aligned}\right\} \quad . \quad (3a)$$

and

$$\left.\begin{aligned} \widehat{xx} &= -P(\alpha + \sin\alpha\cos 2\phi)/\pi \\ \widehat{yy} &= -P(\alpha - \sin\alpha\cos 2\phi)/\pi \\ \widehat{xy} &= -P(\quad - \sin\alpha\sin 2\phi)/\pi \end{aligned}\right\} \quad . \quad (3b)$$

(c) The principal stresses at any point can be expressed in terms of α only ; they are :—

$$\left.\begin{aligned} p_1 &= -P(\alpha + \sin\alpha)/\pi \\ p_2 &= -P(\alpha - \sin\alpha)/\pi \end{aligned}\right\} \quad . \quad . \quad (4)$$

(d) The directions of p_1 and p_2 at any point Q are respectively along and at right angles to the bisector of the angle AQB at the point.

(e) In each of the formulæ 2 to 4 the pressure on the plane z = constant is omitted. The value of this stress is :—

$$\widehat{zz} = -\lambda\alpha/(\lambda+\mu) \quad . \quad . \quad (5)$$

but this is of no importance.

The stresses given by the equations 2, 3, 3a, 3b and 4 are easily shown to be equivalent.

By an extraordinarily simple application of the well-known method of images combined with equation (2) it will be shown that :—

(f) If a smooth vertical wall is placed at QN (Fig. 2) the stresses $\widehat{xx}$ and $\widehat{yy}$ at any point of QN are precisely twice those given by equations (2) or (3), while the shear at QN vanishes.

The stresses at QN are thus :—

$$\left.\begin{aligned} \widehat{xx} &= -P(2\alpha_2 - 2\alpha_1 + \sin 2\alpha_2 - \sin 2\alpha_1)/\pi \\ \widehat{yy} &= -P(2\alpha_2 - 2\alpha_1 - \sin 2\alpha_2 + \sin 2\alpha_1)/\pi \\ \widehat{xy} &= \text{Zero.} \end{aligned}\right\} \quad (6)$$

This case would approximate to the stresses on a retaining wall having a vertical back placed at QN, and incidentally emphasizes the great importance of avoiding vertical continuous planes at the back of retaining walls.

(g) If ON = x (x being greater than a), the normal pressure $\widehat{xx}$ on the back of the wall is zero at the top, increases to a maximum at the point

$$y^2 = [2x(x^2 - a^2)^{\frac{1}{2}} - (x^2 - a^2)^2]/(3x^2 + a^2) \quad . \quad (7)$$

and then diminishes as y is further increased.

(h) At the point of contact of the circle through A and B tangential to QN, a is a maximum for the vertical plane QN, and the pressure at this point is

$$\widehat{xx} = 2aP/\pi. \quad . \quad . \quad . \quad (8)$$

(i) If the back of the wall is placed in the plane of the edge of the loaded strip the normal pressure $\widehat{xx}$ on the back of the wall is a maximum at the top. The value of this maximum pressure is

$$\widehat{xx} = -P \quad . \quad . \quad . \quad . \quad (9)$$

and $\widehat{xx}$ diminishes as y is increased. At a depth equal to the width of the loaded strip

$$\widehat{xx} = -P(\pi - 2)/2\pi. \quad . \quad (10)$$

This case brings to notice the great overturning effect of a heavily-loaded surface near the back of a retaining wall, while (h) affords a ready explanation for the wall shown on Fig. 1 sliding on its base.

(k) If a second smooth rigid vertical retaining wall is placed on the opposite side of the loaded strip the normal pressure on either wall will be again further increased and simple expressions for the value of this pressure at any point will be given.

This case would approximate to that of a pier formed of two retaining walls with the intervening space filled with earth, the latter carrying a load on its surface; a very common case applicable in many harbours.

(l) If the two walls are moved up to the edges of the loaded strip, then it will be shown that the stresses within the region between the walls become simply :—

$$\left.\begin{aligned} \widehat{xx} &= -P \\ \widehat{yy} &= -P \\ \widehat{xy} &= \text{zero} \end{aligned}\right\}$$

everywhere in this region.

(m) A point of special interest dealt with in the Appendix is that in the case of a uniformly loaded strip there is shear on the vertical planes $x = \pm a$ below the edges of intensity P/π at $y = 0$ although there is no shear on the plane $y = 0$ at any point. This constitutes a very interesting exception to the rule that the shears at any point on any two planes at right angles are always equal.

(n) A little consideration of equations (4) shows that for small values of α, $(\alpha - \sin\alpha)$ is quite insignificant, and the principal stress $p_2 = -P(\alpha - \sin\alpha)/\pi$ all but vanishes.

For example, if $\alpha = 18$ deg.

$$\left.\begin{aligned} p_1 &= -P/5 \\ p_2 &= -P/616 \end{aligned}\right\} \text{ approx.}$$

It will thus be seen that for the region well away from A B, or for any point near the surface (x being outside the limits of $\pm a$), the stress system due to a uniform load on A B can be very accurately represented by one principal stress directed along the bisector of the angle α at the point.

Equations 3 and 4 above are not new, as this subject has been treated by Professor J. H. Michell, *vide* Love "Elasticity," 2nd edn., page 208, but the method of obtaining the stresses used in this paper is believed to be novel.

The method of images has been used by Professor Michell in the Proc. of the London Mathematical Society, vol. xxxi, page 183, to determine the stresses due to volume force and for obtaining potential solutions in certain cases.

The basic equations 4 of the Appendix, however, were established by the present writer in the Proceedings of the Royal Society, Series A, vol. xcvii, 1920, page 110, and these equations enable the stresses, in certain cases, to be written out directly by the method of images with surprising ease, and the results obtained by this method are believed to be new. In any case, it is hoped that the article will be of interest and service to civil engineers in the design of jetties, retaining walls, &c.

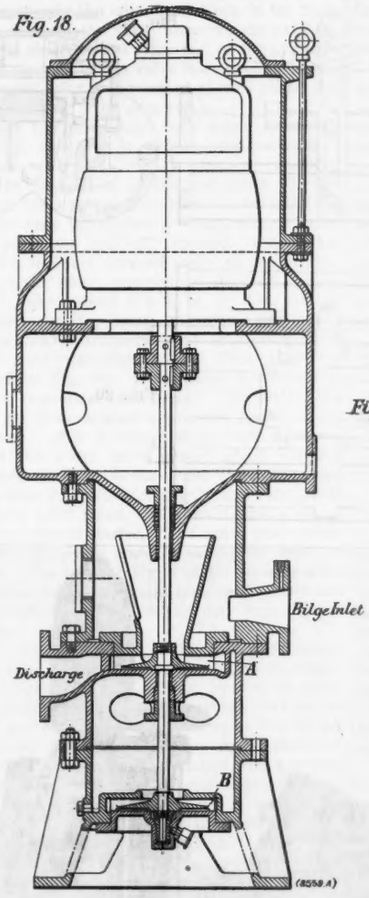
(To be continued.)

BRITISH EMPIRE EXHIBITION: PUMPS AND PUMPING MACHINERY.—II.

MESSRS. Gwynnes Engineering Company, Limited, Hammersmith, have a number of attractive exhibits, some of which, owing to limitations of space, we must deal with on a future occasion. We now propose to notice only their high-lift turbine pumps, emergency bilge pump and low-lift turbine pump for submerged working. The high-lift pump shown is a 6-in. four-stage type "G" machine of the multicellular built-up type, with end units and the number of sections necessary to generate the required head. The end units consist of the suction cover, and the discharge cover and balance chamber. The whole is held together by long bolts, protected from water, passing through the section castings themselves and not merely from flange to flange of the covers. The suction cover is furnished with stuffing-box, neck bush and gland with water seal. The middle sections are of simple cylindrical form. All sections are provided with feet. The discharge end embodies a volute, and the water passing the last ring of guide vanes is discharged into the whole of this, the remaining velocity energy being converted into pressure head before reaching the discharge pipe. The guide vanes are separate rings designed to ensure delivery at low velocity and maximum pressure. The impellers are locked on the shaft between sleeves secured by external nuts, and are driven by a feather key. The internal passages are finished by sand blasting. Renewable impeller eye rings are fitted. Out of balance is provided for by a throttling hydraulic piston in the discharge cover and by Michell thrust blocks in the outer bearing at the discharge end. The latter is capable of continuously carrying the out-of-balance load, and the mechanical combination with the thrust piston makes an arrangement which is less liable to failure under wear than pure hydraulic balancing gives. With the throttling piston arrangement only low-pressure water has to be retained by the gland and the friction losses due to tightening up the latter to hold back high-pressure water are thus reduced. The bearings are carried by pedestals independent of the casing. The driving end bearing is split to facilitate the removal of the bushes. The tail bearing is solid in order to provide a rigid seating for the Michell thrust housing. It can be readily drawn off the machine without dismantling any other part. The thrust bearing is provided with a continuous circulation of oil, the other bearings having oiling rings. The pump exhibited has a capacity of 440 gallons per minute against a head of 376 ft. at a speed of 1,450 r.p.m. The design covers sizes ranging from 4 in. to 12 in., with heads up to 1,000 ft., according to the number of stages. A slightly different pattern is made in sizes from 1½ in. to 6 in. for lower heads.

Messrs. Gwynnes "Invincible" emergency bilge pumps is illustrated in Figs. 18 to 21, page 3. This is of the vertical spindle type, the example shown being driven by an electric motor enclosed in a bell-shaped cover. The pump may be totally submerged without the water entering the motor casing. Risk of damage to the windings is thus avoided. The set is designed to conform to the Board of Trade Regulations requiring in certain classes of ships the installation of reliable submersible pumps driven from a source of power above the bulkhead deck. In Messrs. Gwynnes' pump claims as to reliability are based largely on the small number of the parts involved. These pumps have to be self-priming and this is accomplished without the aid of any reciprocating mechanism, by means of an auxiliary impeller which operates an ejector, circulating water through the latter at sufficient pressure to produce a vacuum. It will overcome any air leakage that may occur in the pipe system. The sectional drawing, Fig. 18, will help to make the arrangement clear. The main pump impeller is marked A in Fig. 18, the auxiliary impeller B being on the same shaft, and submerged in a tank in the pump base. The ejector, which is shown at C, Figs. 19 and 20, and also will be seen in the view, Fig. 21, consists of a simple water jet, air suction and delivery connections and a combining nozzle. When the pump is started the auxiliary impeller B forces water up from the tank through the pipe

PUMPS AND PUMPING MACHINERY AT THE BRITISH EMPIRE EXHIBITION.



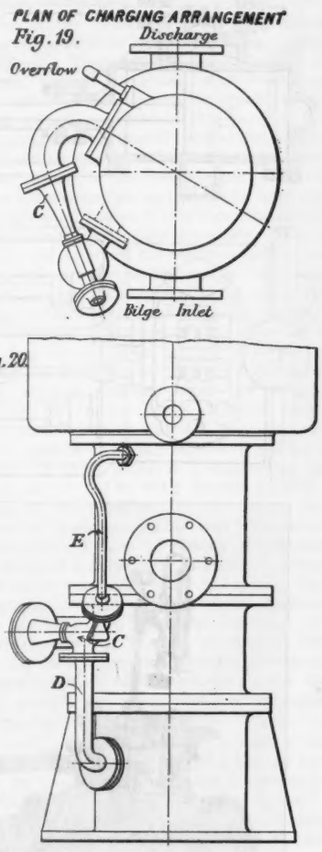


FIG. 21.

FIGS. 18 TO 21. EMERGENCY BILGE PUMP; MESSRS. GWYNNES ENGINEERING COMPANY, LIMITED.

D, and entrained air from the main pump casing is drawn in through the pipe E. The air from the enclosed space above the main pump is thus exhausted and water is drawn in from the bilges through the main inlet. The single main impeller suction is on the upper side so that the thrust on the footstep bearing is partly relieved. Service water is always kept in the tank of the priming impeller. The impellers are of the open vane self-clearing type. The auxiliary impeller works continuously, and the ejector will therefore remove any air coming over with the main suction while the main pump is working. The ejector will deal with waste and small solids without obstruction, but an emergency nozzle is fitted which can be quickly removed for cleaning without further dismantling.

The pump is fitted with a totally enclosed shunt wound D.C. motor of a voltage to suit the ship's emergency lighting set. The spindle gland is water sealed and as will be gathered from what has been said above, works under vacuum so that there is no risk of water passing to the motor compartment above, making extreme tightening of the gland unnecessary. These pumps are made in three sizes with output ranging from 100 to 200 tons of water per hour, fitted with motors from 10½ h.p. to 20 h.p.

The large drainage and irrigation pump exhibited by Messrs. Gwynnes is of a type which has been adopted for the Renala irrigation scheme near Amritsar, in the Punjab. This plant consists of two sets of pumps, one of six units and the other of two units. The pumps of the first set are designed to deliver 22,500 gallons per minute against a head of 8·5 ft., while the other units have a capacity of 18,750 gallons per minute at a similar head. The pumps are totally submerged and are driven through gearing by a vertical-spindle motor above. Figs. 22 and 23 show the general arrangement and give sections of the pump itself. This will be seen to be of the double inlet type, the pump drawing from both above and below, while the discharge is in the middle. The impeller is thus completely balanced so far as hydraulic thrust is concerned, and the bearings have only to carry the weight, part of which is, as a matter of fact, balanced by the proportioning of the two suctions. It will be clear from the sectional drawing that water reaches the eye for the bottom impeller direct through the central bellmouth. It is led to the upper side of the impeller through vertical passages as shown on the left-hand side of the section in Fig. 22. There are nine such passages and they are triangular in section, being arranged between the same number of discharge passages, and acting as guide vanes for the latter as shown in Fig. 23. The vertical suction passages are quite independent of the bell-mouth, and draw from another part of the suction well, so that the supplies to the two impellers do not interfere with each other. Above the pump is a cylindrical casing of tank plating carried up to above discharge water level, and within which is a pipe enclosing the pump spindle. The pump needs no piping either for suction or delivery, being placed directly in the well. The Renala pumps are driven through gearing by electric motors rated at 107 b.h.p. for the larger units and 85 b.h.p. for the small size. The large pumps run at 225 r.p.m., the motors working at 950 r.p.m. The small pumps are run at 212 r.p.m., the motor speed being the same as for the large pumps. The makers state that one of the larger pumps working at 10·25 ft. head at 225 r.p.m. delivers 19,500 gallons per minute, giving an efficiency of about 74 per cent. With the pump submerged, no priming is, of course, necessary. The simplicity of the design makes the pump cheap, easily erected and easily maintained. Other appliances shown by Messrs. Gwynnes Engineering Company we must defer for the present.

The exhibit of Messrs. Hayward-Tyler and Co., Limited, of 99, Queen Victoria-street, E.C.4., whose works are at Luton, Bedfordshire, comprises a number of pumps all of which it is unfortunately impossible to deal with in detail. Of greatest interest, perhaps, are two pumps employing a new type of valve gear. These are duplex pumps, one of them being of the vertical type and the other of the horizontal pattern. The horizontal pump is a 5 in. by 3 in. by 8 in. machine for delivering oil fuel to the burners of oil fuel installations of the pressure type. The pumps are fitted with Twells valve motion for which the makers claim a number of advantages. Among these is the fact that the gear is positive in action. It will start in any position when steam is turned on, giving an absolutely full stroke under all possible conditions. Steam economy results from smaller clearance volumes due to the use of one port only at each end of the steam cylinders, instead of the two employed in the ordinary duplex pump. In this type of pump the body is specially designed for dealing with viscous oils and large passages and valves of unrestricted area are provided. An adjustable relief valve is also fitted by which the full quantity of the oil pumped can be by-passed without appreciable increase in the delivery pressure. The makers claim that this type of pump is superior both to the single cylinder pump often used and the ordinary duplex so commonly used abroad, as it can be run at quite low speeds and with heavy viscous fluids and against a vacuum without risk of making short-strokes. This pump may be seen in operation at the Exhibition, run on compressed air, and the regularity of the pressure maintained

PUMPS AND PUMPING MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

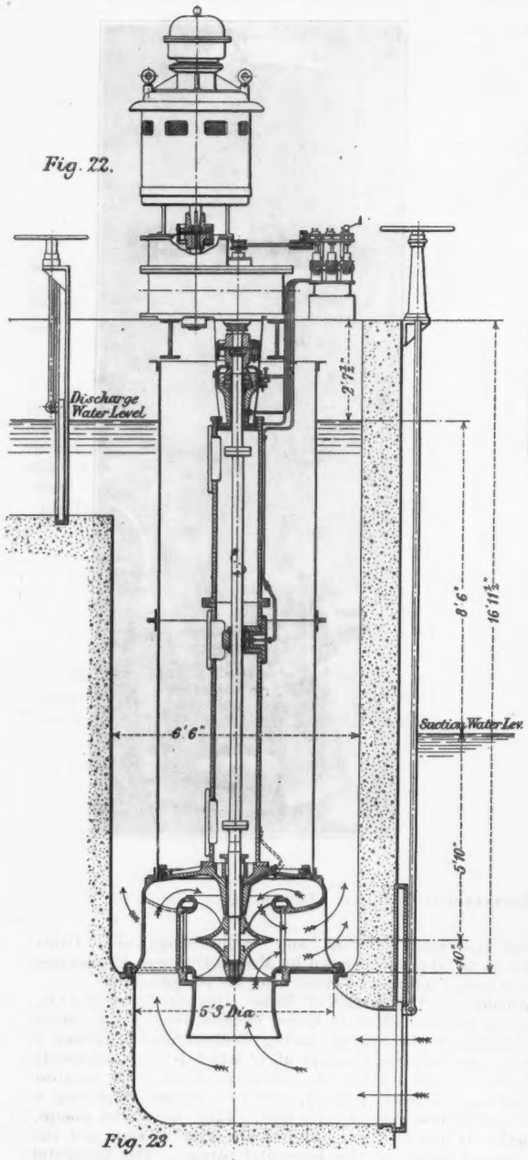
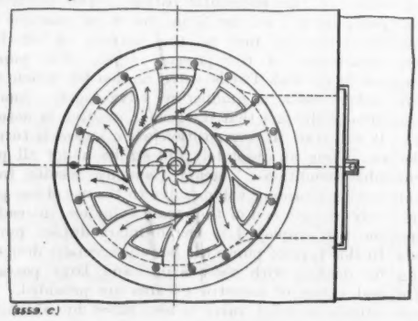


Fig. 22.

Fig. 23.



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FIGS. 22 AND 23. LOW LIFT SUBMERGED IRRIGATION PUMP; MESSRS. GWYNNES ENGINEERING COMPANY, LIMITED.

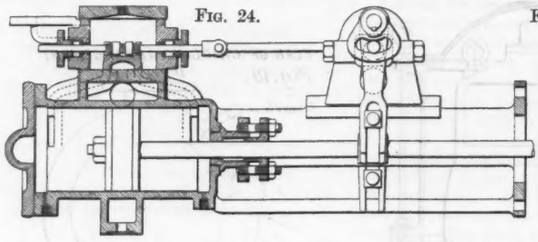


FIG. 24.

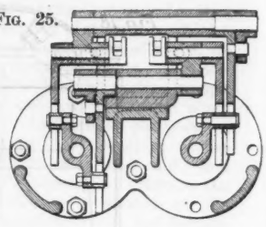


FIG. 25.

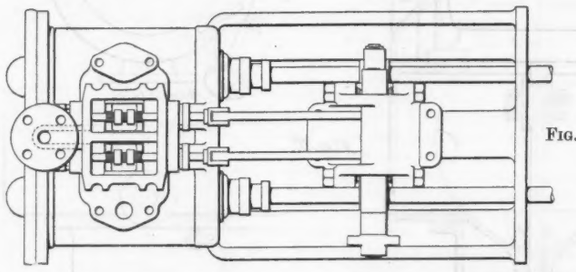


FIG. 26.

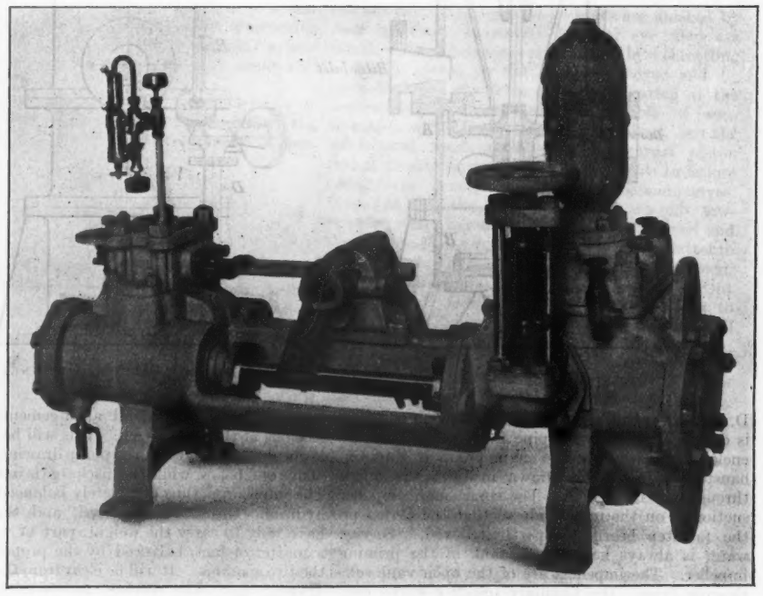


FIG. 27.

FIGS. 24 TO 27. DUPLEX PUMP WITH TWELLS VALVE GEAR; MESSRS. HAYWARD-TYLER AND CO., LIMITED.

is well worthy of notice. The pump itself is shown in the reproduction from a photograph given in Fig. 27, annexed, while with the aid of the accompanying drawings, Figs. 24 to 26, and Figs. 28 and 29, on Plate I, the action of the Twells valve motion may be followed.

In the Twells gear the greater part of the movement of each valve is derived from its own piston rod, instead of, as is usual with the duplex gear, from the opposite side of the pump. A short supplementary movement from the second side is, however, combined with this in the manner we shall proceed to describe. Each cross-head of the pump works two forked rocking levers, as will be clear from Fig. 25, which gives a cross section of the motion. Dealing with the left-hand side of this figure the outside lever will be seen to transmit a rocking motion to a short arm inside. The latter is coupled to the valve spindle in the usual manner. The fulcrum of this lever is not fixed in the ordinary way, but is formed in the end of the short arm of a rocking lever carried, as will be seen, through to the other side of the pump and driven off the second cross-head. This side of the pump is shown in Fig. 27, and the two drawings (Figs. 24 and 28) will make it clear that the forked arm on this side, instead of being fixed to the horizontal spindle of the rocker, works freely on the latter, and transmits motion to it only by means of a pin on the lever working in a slotted quadrant on the spindle. The slot allows the lever to move for about three-quarters of its stroke without affecting the quadrant, but for the last quarter carries the quadrant, and consequently the fulcrum lever of the first (left) side with it. The motion is duplicated for the second side, but the parts are necessarily somewhat modified in order to secure compactness of design.

Considering the motion of one side only for the moment, if the piston is as shown in Fig. 28, at the end of its stroke, and the port uncovered, on steam being admitted the piston will move forward. This movement will work the valve through the valve rocking lever, the fulcrum being, for this phase, supported by a fixed, adjustable stop on the pump frame. The motion continues until the valve is closed, at which point the fulcrum is swung over by the movement of the slotted quadrant as a result

of the action of the other side of the pump. This pushes the valve still further in the direction of its original movement, the valve rocking lever fulcrum being temporarily the cross-head block in the fork. This last move of the valve uncovers the exhaust, and admits steam to the other end of the cylinder. Thus, the opening of the valve is controlled by the opposite unit, but the movement of each piston rod effects the closing of its own valve.

Although this description may sound somewhat complicated, the gear is simple and very effective, giving extremely steady pumping pressure, due to the interaction of the two units. If one unit tends for a moment to move faster than the other, the gear introduces a compensating effect and its ports are not fully opened. Full piston strokes are, however, assured under all conditions.

Perhaps the most conspicuous item on Messrs. Hayward-Tyler's stand is a 7½ in. by 8-in. vertical duplex piston cooling pump, one of two sets for the motor mail boat Indrapoera now building in Holland for the Rotterdamsche Lloyd. This pump is illustrated in Fig. 30. It is driven by means of worm gear from an electric motor. The set delivers 70 tons per hour against a pressure of 56 lb. per square inch. It is of exceptionally rigid construction and the worm drive ensure silent working. The motor is of 22 brake horse-power capacity, working with 220 volt d.c. supply and running at from 700 to 1,000 r.p.m. It is fitted with a special marine type barrel starter. The worm gear reduction gives the pump crank a maximum speed of 57 r.p.m. The pump body is of the usual marine type, having hard gun-metal removable liners and easily accessible valves of the disc type, spring controlled.

Fig. 31 shows a new and simple pattern of duplex steam pump just brought out by Messrs. Hayward-Tyler. The size shown is a 7½-in. by 5-in. by 10-in. vertical pattern, capable of delivering 6,000 gallons of water per hour against a pressure of 180 lb. per square inch. The design is very straightforward, two steel tension bars in combination with a central cast iron column ensuring correct alignment, and rigidity, while from our illustration it will be evident that accessibility has been kept prominently to the fore in the design. The pump body is fitted with brass liners and gun-metal valves, spring controlled. The valve motion is simple, strongly constructed and provided with large surfaces. These new pattern pumps are all made with a foot, this type now being more generally favoured than the bulk-head design.

Another pump shown by Messrs. Hayward-Tyler, is a rotary pump of the gear type of a capacity of 15 tons of oil fuel per hour against a head of 30 ft. This pump is also one built for the motor ship Indrapoera, referred to above. The set includes a 3 b.h.p. d.c. motor running at 800 r.p.m. on 220-volt supply, and a separate reduction gear running in an oil bath. One rotor spindle is driven direct from the reduction gears, the second being driven by gearing from the first, allowing the rotors themselves to be designed to the most effective profile. The rotor speed is 160 r.p.m. This type of pump has been tested under severe conditions on oil-fields with oil heavily laden with sand, and the firm has such confidence in the design that they manufacture the type in sizes up to 200 tons per hour.

We can only briefly refer to some of the remaining exhibits at this stand. A 22 in. by 14 in. by 18 in. horizontal duplex cargo oil pump is shown of the firm's standard pattern, of which over 150 of this size alone have been supplied to tankers, while the firm has furnished duplex oil cargo pumps altogether to more than 300 tank ships. Other pumps are representative of waterworks practice, two treble barrel pumps for high heads being shown. A pump of unusual character is the 7 in. by 1 in. by 7 in. single-cylinder hydraulic-pressure pump which was first used in 1897 in connection with tunnelling shields employed in the construction of the London Tube railways. We dealt fully with this interesting pump as long ago as 1898,* in a series of articles describing the construction of the Central London Railway, when this pump was applied to shield working for the first time. We need only add that since that time Messrs. Hayward-Tyler and Co., Limited, have made no less than 120 of this size of pump alone in connection with later developments and the pump is still in good demand for tunnelling work. Messrs. Hayward-Tyler's exhibit is completed by steam, boiler and fire fittings, valves for pumping machinery, &c.

One of the other firms showing a considerable range of pumps is Messrs. Tangyes, Limited, Birmingham. These include duplex pumps and ram pumps, as well as examples of centrifugals. Of the latter a 2-in. pump for heads up to 35 ft. is shown. The volute of this pump is bolted to a circular vertical face of the bed plate, and is made with similar flanges on both sides, the suction cover being similar to the bedplate face. The volute is thus made reversible and serves for both right-hand and left-hand pumps of this type, while standardisation of the flanges makes it possible to turn the body of the volute about the centre to any of a number of positions to get an inclined or other position for the discharge. The type of pump now under notice admits of five variations of the kind, giving vertical or horizontal discharge or the choice of three at 45 deg. up or down, or 135 deg. up. Another pump for heads up to 75 ft. is shown in the 6-in. size, its main feature being the vertically split casing, the pump being designed specially for transport by pack animals, &c., for which the parts must be small and capable of making balanced loads. A third pump is a single-stage pump for heads up to 120 ft. with divided suction to both sides of the impeller. In this again the volute body is made reversible and standardised, the latter giving a choice of various combinations of the position of suction and discharge. Normally the suction is vertically below the pump, but can be arranged in eight different radial positions, while the discharge also has eight positions. It will be evident, however, that on account of the fouling of the two connections certain combinations are impossible, but with these eliminated the design still gives a very wide choice of arrangement.

The exhibit of The Mirrlees Watson Company, Limited, of Glasgow, is largely devoted to condensing plant, and two of the pumps exhibited by the firm are for use in connection with condensing arrangements. One of these is a new opposed impeller centrifugal extraction pump for condensate. This is a 3-in. pump with a capacity of 200 gallons per minute from vacuum of 29 in., with barometer at 30 in., and against a total head of 50 ft., when running at 1,440 r.p.m. A cross section of this pump is shown in Fig. 33, Plate II, while the reproduction in Fig. 32 shows the pump with cover removed, as it is to be seen at the exhibition. The chief feature of this design is that the impellers, which are double shrouded, are placed sufficiently far apart for the inlet to be arranged between them, the two spirals being branched to a single outlet. In this way the space A in the interior only is under suction conditions, while the spindle stuffing boxes and glands are under the discharge pressure existing in the spirals. This is the reverse of the usual practice and completely eliminates what is undoubtedly one of the principal sources of air leakage into closed feed systems, viz., gland leakage at the pump spindle. We understand that this pump has been extensively copied in countries in which the design has not been patented, a tribute to the value of the principle on which it is designed. In mechanical construction the pump will be found to be excellent. The impellers are of polished gunmetal, carefully balanced. Renewable rubbing rings are fitted to the central eyes of the casing. The nickel-steel shaft has bronze sleeves, and the bearings are of the ring oiler type suitable for continuous working over long periods.

Another pump for condensing purposes shown by the firm is a 10-in. low lift centrifugal intended primarily for circulating cooling water through surface condensers, but suitable, of course, for other service involving considerable quantities of water at small heads. This pump is shown in the drawing, Fig. 34, and opened up in the illustration, Fig. 35. This machine has a single balanced impeller drawing from both sides the suction being divided and brought up on either side of the central spiral. The casing is split on the horizontal. The suction and discharge are in a horizontal line below the pump. The shaft is fitted with renewable sleeves, and the casing eyes with renewable rubbing rings. The glands have each two sets of packing, the space between them being kept under pressure by means of connections with the spiral. The bearings are of the ring oiler type, the shaft being fitted with oil throwers. The pump shown has a capacity of 2,600 gallons per minute against a head of 59·5 ft. at 960 r.p.m.; and shows an efficiency of 84 per cent. The efficiency curve for this pump indicates an efficiency of over 80 per cent. at all deliveries between 2,000 and 3,000 gallons per minute.

Two other pumps which we now wish to refer to are the high lift centrifugals shown by the Mirrlees Watson Company. Both these are two-stage pumps, one being shown dismantled, and the other running under throttled conditions. These pumps are of the ring type, and can be built up to meet any required head by bolting together a suitable number of interchangeable sections. They are of robust design, and are intended specially for mine and other heavy duties. A section of a two-stage pump of this type is shown in Fig. 37, Fig. 36 showing a photograph of one of the sizes on exhibition. The hydraulic balance is attained by means of a double face differential balance disc arranged so that if, due to gritty water, wear cannot be avoided, the impellers will retain their correct position. The impellers and diffuser rings are of special high-tension bronze and the walls of the water passages are highly finished. The outer bronze guide ring is finished to an easy curve to the point where the water passes over into the suction passage of the next impeller. Bronze renewable rings are fitted wherever wear is likely to occur. The shaft of nickel steel has bronze renewable sleeves and the stuffing boxes are water sealed. The end bearings are split horizontally, ring lubricated, and have cast-iron bushes lined with white metal. Oil throwers and oil catchers are fitted, oil gauges also being provided. The ends nearest the stuffing boxes are arranged to prevent any risk of flooding with water. Water cooling for the bearings may easily be arranged. One of the pumps of this type shown is a 5-in. pump for a duty of 570 gallons per minute, against a head of 200 ft. at 1,440 r.p.m. The other, at work, is a 3-in. pump, and, running at the same speed, will deliver 150 gallons per minute against 150 ft. head. Curves for the former show an efficiency of 72 per cent. at the delivery named, and over 70 per cent. between about 370 and 670 gallons per minute.

* See ENGINEERING, vol. lxv, page 329.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page 824 of last volume.*)

Metallurgy.—A glance at Dr. Rosenhain's report on the Department of Metallurgy and Metallurgical Chemistry may suggest to the reader that chemists have some justification for regarding their science as the parent science. The department has its share in most of the work done in the Laboratory because composition, purity, corrodibility, heat-treatment, and physical structure will generally come in question. Thus in the research on the influence of mass on the properties of heat-treated nickel steels, the Engineering Department has been associated with the Metallurgy Department. Bars of nickel steel, from 2 in. to 10 in. in diameter, oil-hardened at 840 deg. C., were not found to conserve true hardness when more than 3 in. in diameter, and subsequent tempering at different temperatures did not really give uniform specimens, so that more drastic methods of quenching or nickel steels further containing chromium may have to be adopted. The mild steel of gas cylinders, chains, and hooks fails rather by shock than by fatigue, and low-temperature annealing promoting a coarse crystalline structure may, so far from being advantageous, be positively injurious. The subsequent heat-treatment of correctly normalised chains and hooks would then appear to be unnecessary; but normalising of wrought-iron would require temperatures above 1,000 deg. C., realisable only in special furnaces, and would introduce risk of distortion.

In the study of ferrous metals, to which as much

attention is now paid as to light alloys, use is made of the high-frequency Ajax-Northrupp furnaces which are evacuated by means of an American high-Vac Cenco pump, an oil pump of the rotary type. The crucible, generally a double clay cylinder with an intermediate packing of aluminium grog, is so mounted in the outer alundum cylinder, by means of blocks of carbon, zirconia, &c., that it occupies the middle third of the furnace. In spite of this the top layer of the metal may still be solid when the main mass of the metal is already superheated, so that the crucibles, apt to crack owing to the rapid expansion of the rapidly fusing metal, may also be burned through. Molten iron and oxide attack most materials; even alumina absorbs the oxide and shrunk magnesia is not satisfactory. But it was demonstrated how magnesia crucibles can be pressed and glazed internally by means of the radiated heat of an electric arc playing between two carbon electrodes.

With the aid of electrolysis and these furnaces which avoid contamination by carbon gases, inevitable in the otherwise convenient carbon-ring furnaces, pure iron, chromium, &c., are being prepared, Chromium is deposited from aqueous chromic-acid solutions by means of lead anodes; the final dendritic chromium has a pure steel-grey colour and is not oxidised by exposure. Traces of oxygen are very difficult to suppress, as well as to determine, in these metals and also in aluminium. The latter metal, it is curious, has not been obtained yet in a purity exceeding 99·83 per cent.; in Germany purification is effected by granulating the metal and treating the granules with chemical reagents which will remove most of the iron, but not of the silicon. We can only mention the researches on the solubility of gases in metals, which is determined by measuring the gas adsorbed by the metal. Reports on the researches on die casting and on cutting tools are in preparation.

Physics.—With its four divisions of general physics and heat, radiology, sound and optics, the Physics Department is taking part in the varied researches on international critical constants, the centigrade-thermodynamic temperature scale, heterochromatic photometry and thermal conductivity. The heat insulation and cold-storage work of Dr. E. Griffiths at the Laboratory has been interrupted by his journey last year to Australia, by request of the Food Investigation Board, for the special purpose of improving the oversea apple transports and the control apparatus needed for this object; four ships were equipped with apparatus before any decision was taken as to the most satisfactory type of instruments. With respect to clinical thermometers it is satisfactory to note that the numbers submitted still remain very high, although the legal enforcement of the tests has been abandoned. The makers agreed this year that the tubes should be made of lead glass; that this regulation is not always observed is proved by a simple X-ray photography test; the rays show at once which tubes of a bundle are quite pervious to the rays and, therefore, of ordinary glass. This work is done in the Radiology Division, which is also in charge of the inspection of X-ray rooms. Thanks to the rules of the X-Ray and Radium Protection Committee, which are recognised in other countries, the state of affairs has become better. The lead equivalents of various materials, i.e., the relative thicknesses of lead of the same X-ray protective powers, are rather curious. The steel value is 0·15 (lead = 1), brass 0·25, bricks and concrete about 0·01, various woods down to 0·001 and less; plasters consisting of baryta and some cement are of the order of 0·3, and that value is not improved by mixing iron turnings, which cause trouble by rusting, with the plaster.

The Sound Division is being equipped in its new quarters in the basement of Bushy House, where two sound-proof chambers, isolated with layers of felting and by 6 in. air space between the double-walls, have been constructed, they are approached by triple doors. The equipment comprises valve oscillators, Rayleigh double resonators, and portable cabins easily dismantled for observation.

The Optics Division has completed the constant temperature room which is indispensable for precise optical measurements. Most of the photographic lenses submitted for test in increasing numbers are still of foreign origin; but Jena glass, as distinct from the old silicate flints and crowns, is not essential for many lens combinations. In this and other work the new camera lens interferometer of Messrs. A. Hilger is an instrument of unique value, because the bands indicate the presence of aberrations where they arise, at the lens itself and not at the image where the effects due to different parts of the lens are very difficult to disentangle. Important research are also proceeding on colour standardisation and a laboratory standard of white light, and, further, on coloured glass for railway signals and aircraft, particularly also on the best third colour least likely to be confounded with green and red.

Electricity Department—Electrical Standards and Measurements.—The question has been raised whether a density specification should be included in the definition of the international ohm in view of the fact that the isotopes of mercury differ by one or two parts in 100,000 as to density. The division does not consider this necessary, because recent re-examinations of the old mercury standards again indicate the possibility of various greater errors. The report draws attention to the importance of Mr. D. W. Dye's work on inductance standards and the need of defining their connections, on the multi-vibration wave meter, on a transformer method for producing small radio-frequency currents suitable for measuring the strength of signals and on the use of the cathode tube for absolute measurements for radio-frequency.

Wireless Division.—The radio-transmitting station of the laboratory is now sending out, between the hours 15 and 16 on alternating Tuesday afternoons, standard radio frequency signals, corresponding in wave lengths to the range 750 to 5,000 metres, for the Admiralty and the general public. The observations on radio-direction finding and its vagaries with day and night, the weather, local features, &c., are still proceeding; we have repeatedly touched upon these troublesome problems, which laborious examination of the data collected may help to clear up. When the direction of the electric and the magnetic waves are separately determined, the wave form and its tilt can be deduced. The manifold demonstrations of last Tuesday exemplified such measurements, as well as the determination of signal strength and amplification ratios.

Electrotechnics—Alternating Current.—We stated in our introduction that no additions had been made to the buildings. In reality a high-tension laboratory, a two-storey building, is in course of construction. Plants for 250 kilovolts exist in England, elsewhere 1,000 kilovolt plant has been constructed, and the Laboratory is no doubt wise in having decided to equip the new spacious laboratory with transformers capable of giving 1,000,000 effective volts. In the old building the instalment of two motor-generator sets, each of 30 kv.a., for currents of 1, 2 or 3 phases, at frequencies from 20 to 75 cycles has been completed. The machines have been supplied by Messrs. J. H. Holmes and Co., of Newcastle. The motor is fed from a battery and, to ensure further steadiness of the currents wanted for measurements, two of the slip rings are running in mercury troughs. Among the apparatus demonstrated was a high-voltage air condenser, a big horizontal copper tube provided with bell-shaped ends for diminishing the potential gradient at the end, which is used for measurements on insulation materials, and an apparatus exemplifying the rotation of dielectrics in a three-phase field. Excited by such a field three metal balls turned at the rate of 50 r.p.s. A cylinder of celluloid placed in that field, absorbing some of the alternating energy was dragged round by the field and began to spin about its axis, at a slow speed which was the greater, the poorer the insulating material, but never reached the field speed.

(To be continued.)

THE PORT OF HULL.—A special British Empire Exhibition supplement has been issued by the *Hull Daily Mail*, giving interesting illustrated articles on the history of Hull, particulars concerning the port, the dock and transit facilities which it offers, with information on the commerce and industry of the city and neighbouring district.

BRITISH EMPIRE EXHIBITION; RAILWAY MATERIAL.—IV.

A VERY interesting exhibit at the stand of Messrs. Cammell Laird and Co., Limited, is a "Sentinel-Cammell" steam rail coach. This vehicle has been built at the company's Nottingham works, in collaboration with the "Sentinel" Waggon Works (1920), Limited, of Shrewsbury. The former are the builders of the vehicle itself, the latter being responsible for the power unit. The vehicle has been designed with the object of reducing expenses on branch lines and for dealing with periods of light traffic, while it is equally suitable for the development of traffic where small passenger loads are available at frequent intervals, thus competing with the omnibus type of service. The principle of rail motor-coaches has, of course, been developed by the railway companies to a considerable extent in past years, but the Sentinel-Cammell coach represents quite a distinct type of construction.

The car is illustrated in Figs. 60 to 72 on pages 7 and 8, and on Plate III. A general elevation is given in Fig. 60, and outside view in Fig. 68, Plate III. One of the main compartments in the interior is shown in Fig. 69. Fig. 70 shows the driver's and luggage compartment; Fig. 71 is a view of the engine compartment, while Fig. 72 shows a passenger section partitioned off from the main interior. This small compartment seats 12 passengers and the main saloon 44, making for the coach shown a capacity of 56. A plan, slightly varying from the vehicle at the exhibition, is given in Fig. 61, page 7. Figs. 62 to 64 relate to the trailing bogie, while the power unit is illustrated in Figs. 66 and 67. Fig. 65, representing a section of the driving wheels, is referred to below. The main feature of the construction is that the body of the coach is carried by a steel underframe, supported at the trailing end in the ordinary way by the bogie shown in Figs. 62 to 64, while at the front end it is pivoted to the power unit frame, at a point behind the rear axle of the latter, as shown in Fig. 67, the weight of the coach on this unit being counter-balanced by the position given to the boiler. The coach body and the bodywork covering in the power unit are connected by means of flexible collapsible fabric jointing, so that relative movement on curves is provided for. The driving wheel-base is 7 ft. and the trailing bogie wheel-base 5 ft. 6 in., the distance between bogie centres being 42 ft. 10 in. With the great flexibility permitted by this arrangement of units, curves of 3 chains radius can be negotiated with ease and safety, thus making the vehicle eminently suitable for the development of light branches, &c. The overall length of the coach shown, which is for 4 ft. 8½ in. gauge, is 56 ft. 5 in., with a width of 8 ft. and height of 11 ft.

The power unit consists practically of a standard "Sentinel" boiler and set of engines of the type so well known at home and abroad. The drive to the two axles is by roller chain and sprockets through an intermediate shaft, as will be clear from Fig. 66. The boiler is of the vertical type with 30 cross tubes, and having a total heating surface of 58·5 sq. ft. The tubes are straight and inclined upwards across the fire box, the whole of the latter can be unbolted and dropped out for examination at any time. The fire grate is 3·97 sq. ft. in area. A superheater is added providing 14·5 sq. ft. of surface, the steam having a temperature of 460 deg. F (230 deg. of superheat) and a pressure of 275 lb. per sq. in. Feed heating is arranged for a feed temperature of 200 deg. F. in normal working. The engines consist of 2 double-acting cylinders, 6·75 in. in diam. with a stroke of 9 in. The maximum revolutions are between 600 and 650 p.m. The diameter of the driving wheels is 30 inches and the reduction between the crankshaft and the the wheels is 39:25. The annexed table gives further particulars of the unit at various speeds:—

Speed	m.p.h.	10	20	30	35
Engine ...	revs. per min.	175	350	425	602
B.H.P. at 33⅓ p.c. cut-off ...		54	60	58	47
Tractive effort	lb.	2,025	1,125	725	503

For short periods at starting and during acceleration with a cut-off of 80 per cent. a tractive effort of between 4,000 and 5,000 lb. can be exerted.

The steam consumption per brake horse-power

SENTINEL-CAMMELL STEAM RAIL MOTOR AT THE BRITISH EMPIRE EXHIBITION.

Fig. 60.

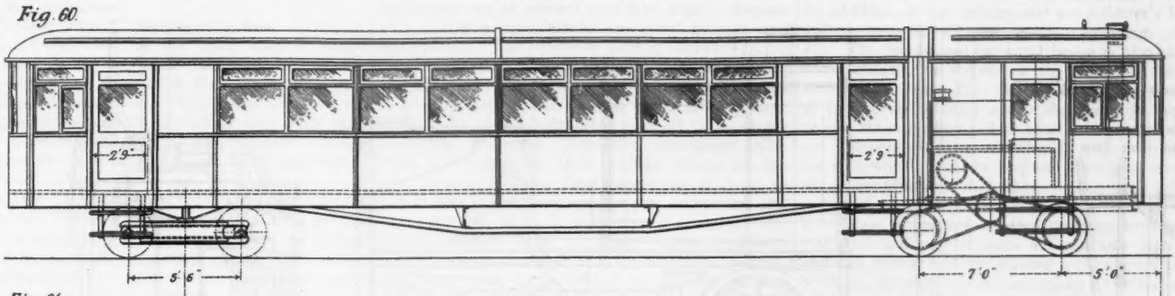


Fig. 61.

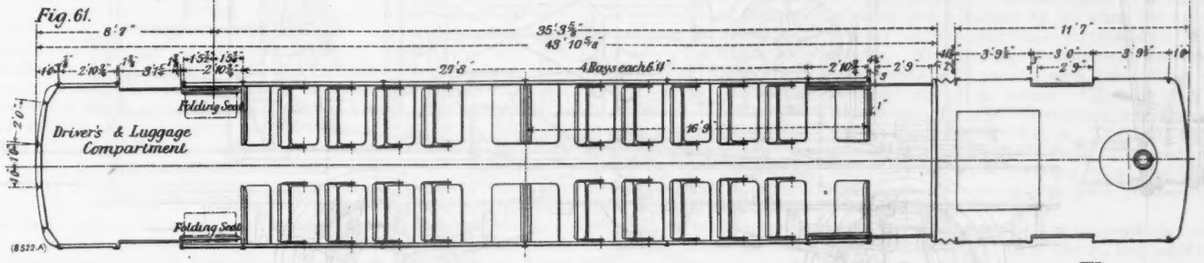


Fig. 62.

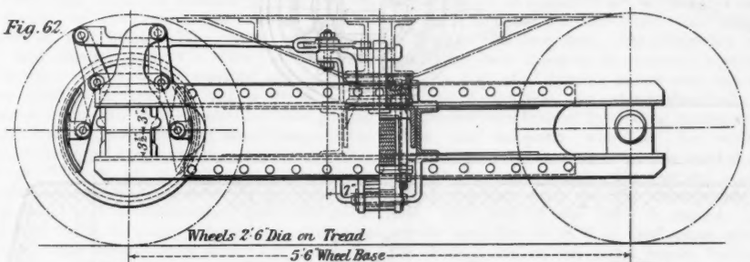


Fig. 63.

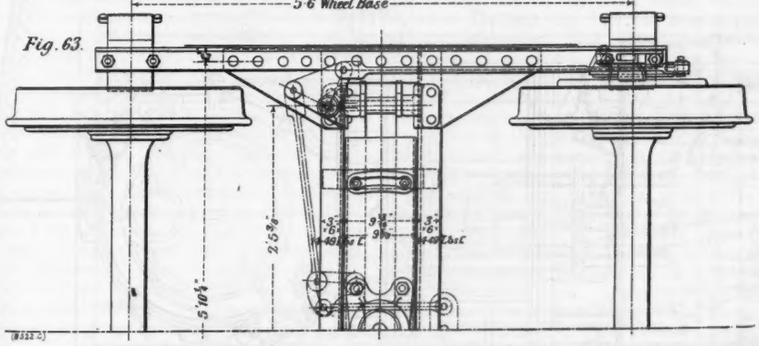


Fig. 64.

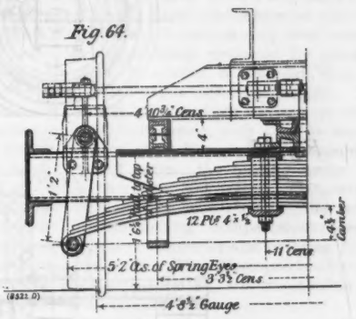
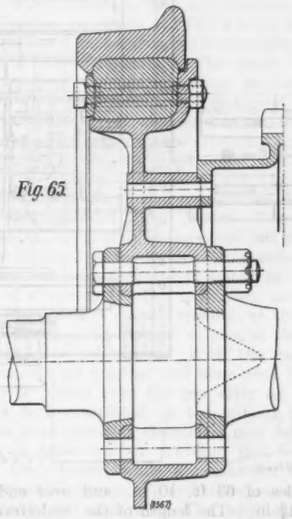


Fig. 65.



ranges between 20 and 25 lb., under normal conditions, about 1,500 lb. of water being evaporated per hour. With coal of a calorific value of 14,500 B.Th.U., the fuel consumption is about 3 lb. per brake horse-power hour. With average conditions of curves and gradients about 4 gallons of water are needed per train mile, and the coaches have water tanks of 200 to 300 gallons capacity. In Fig. 66 the water tank is shown in the engine compartment. In some cases it is placed below the body underframe. With 200 gallons of water and otherwise in working order the weights are 10 tons 15 cwt. at the power unit bogie, and 6 tons 8 cwt. at the trailing bogie, making a total of 17 tons 3 cwt. Fully loaded these are increased respectively to 11 tons 15 cwt., 8 tons 18 cwt. and 20 tons 13 cwt.

Normally the coach travels engine first and the driver has all levers, &c., naturally close at hand. When running trailing end first the driver is in the then leading compartment, where, as shown in Fig. 66, page 8, he is provided with all necessary controls with mechanical connection to the power unit. The power unit is carried on laminated springs over the axle boxes, the latter being without guides but provided with adjustable radius rods. The trailing bogie, Figs. 62 to 64, has one large inverted laminated spring in the bolster only.

Braking is by expanding brakes working inside drums fixed to the wheel centres on the outside, one pair of wheels being braked per bogie. Both hand and power braking are arranged for, while the engine can also be used as a compression brake. Little need be said by way of description of the body which, however, is neatly made and finished, of steel construction to provide maximum strength with minimum of weight.

The type of coach can be built for any gauge and climate, and at present vehicles are under order for Australia, South Africa, India, European and other countries. The first was put into service sometime ago in Jersey where road competition has been successfully met by the new facilities thus made possible. In the first ten months over 250,000 passengers were carried by this vehicle on a consumption well under 5 lb. per ton-mile and over-all cost including fuel, oil, water, staff, depreciation, &c., of less than 6*d.* per ton mile. A second coach has now been in operation on the Jersey Railways and Tramways for some time. We may mention that the service on the Jersey line involves a run of 3·75 miles with an average of 6 stops on a booked timing, start to stop, of 15 to 17 minutes, thus requiring very rapid acceleration. These conditions are well met by these coaches.

The most conspicuous exhibit at the stand of Messrs. Cammell Laird and Co., Limited, is probably the Pullman car built by the Midland Railway Carriage and Wagon Company, Limited, of Birmingham. It is an excellent example of the quality of work for which these makers are so well noted, though, owing to the presence of other similar cars it may not win attention in the same manner as the more uncommon examples of rolling-stock to be seen alongside it, and of which we have already mentioned one example. Another exhibit, a Bengal-Nagpur 40-ton hopper wagon, we shall refer to later. The Pullman vehicle, to which we now devote ourselves is a first-class buffet car having a length over buffers of 65 ft. 10 in., over

SENTINEL-CAMMELL STEAM RAIL MOTOR AT THE BRITISH EMPIRE EXHIBITION.

Fig. 66.

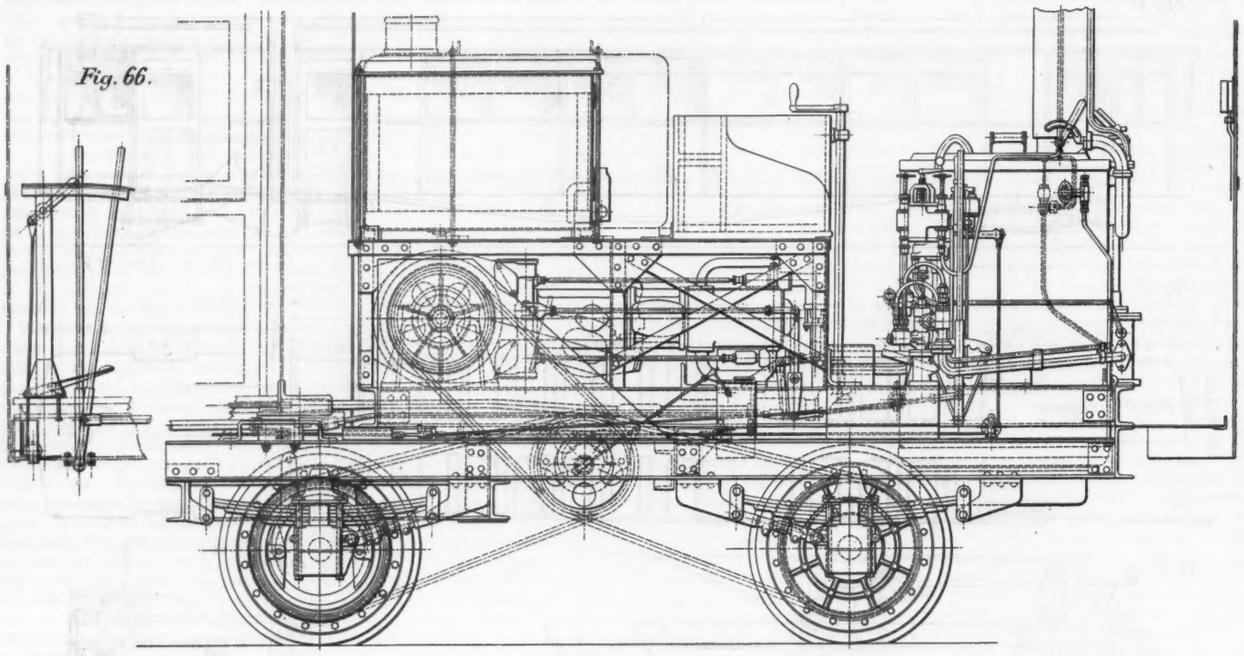
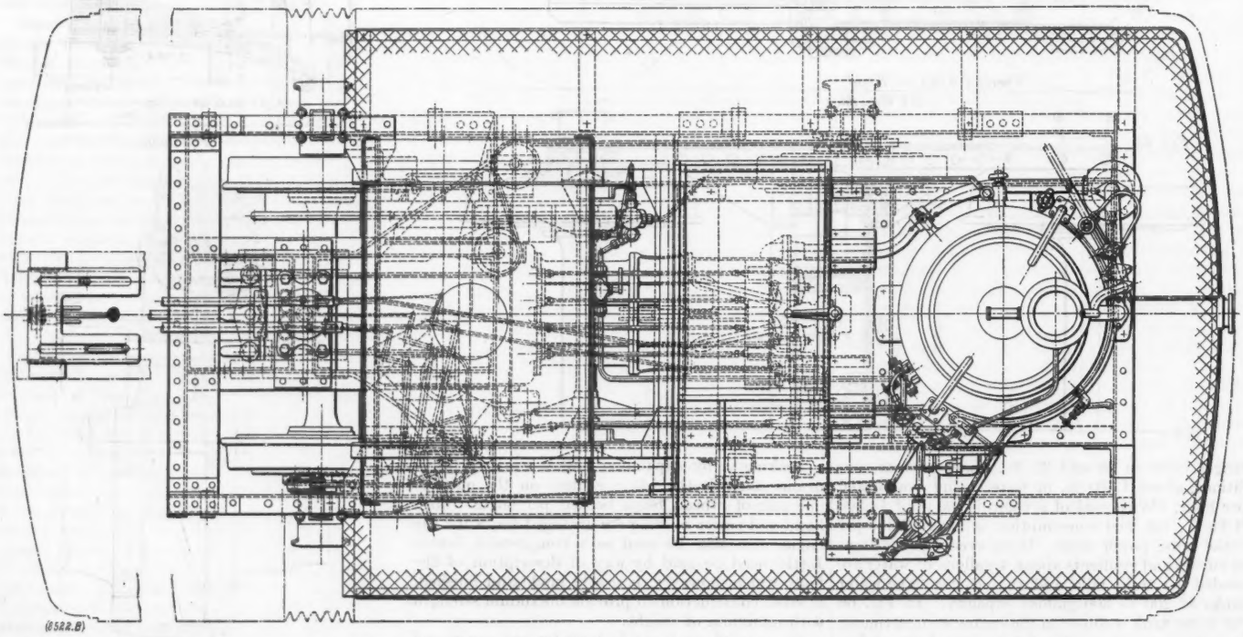


Fig. 67.



(8522.8)

vestibules of 63 ft. 10 in., and over end pillars 57 ft. 1¾ in. The length of the underframe over headstocks is 62 ft. 4 in. The height from rail to top of roof is 12 ft. 5 in., and the width over cornice 8 ft. 7 in. The inside width in the compartments is 7 ft. 9½ in. The car is mounted on two four-wheel bogies of 10 ft. wheel base, centred 43 ft. 4 in. apart, the wheels being 3 ft. 6 in. in diameter on the tread, and the journals by 10 in. by 5 in. The underframe is of steel and is provided with truss rods.

The car has a seating capacity of 22 passengers disposed as follows: ten passengers in a large saloon, eight in a small saloon and four in a private compartment. The length of the large saloon is 17 ft. 9 in., and of the small one 13 ft. 6 in. The interior finish of the saloons and private compartment is in finely figured mahogany in Eighteenth Century style, with shaped mirror panels and carved and guilt ornaments. The clocks at the ends have gilt sun-ray surrounds. The floor is covered with a blue trellis carpet, and the upholstery of the chairs is in blue buffalo hide. Parcel racks, table lamps, &c., are finished in lacquer gilt. The tables are removable. They have tops of polished mahogany, to match the interior panelling, &c., and are protected by plate glass. The ceilings of the saloons and private compartment are domed with coved sides and panel centres. Ventilation is provided for by torpedo ventilators and ceiling fans. Aluminium framed sliding lights are fitted above the windows. The vestibules and corridors are also finished in polished mahogany, the floor of these parts being laid with interlocking rubber tiling. The lavatory compartment is finished with polished mahogany. The floor of this compartment is laid with decolite. A pedestal wash basin is provided in the lavatory, fitted for hot and cold supplies. Large mirrors are fixed to the cross partition.

The kitchen and pantry, occupying one end of the car, are equipped with the necessary sinks, hot and cold water supplies, glass cupboards, gas-heated stoves, &c. The floors are laid with decolite. Water is carried in a large roof tank above the kitchen. Galvanised bins are arranged beneath the kitchen and pantry floors, and ice chests are fitted in the corridors. The kitchen and pantry are both painted throughout in white enamel, giving a very clean effect to the whole.

The exterior of the car is painted in the standard Pullman colours of umber and cream, with gold lining and the company's coat-of-arms. The car is dual fitted and has the standard heating apparatus,

electric light installation, &c. The buffing and draw gear enable the car to be worked with other central buffer stock or with vehicles fitted with screw link couplings.

On a large stand, neighbouring that of Messrs. Cammell Laird and Co., the many uses of rubber for railway work are well exhibited by Messrs. George Spencer, Moulton & Co., Limited, Central Buildings, Westminster. The most conspicuous examples shown consist of buffing and draw gear fitted in sections of typical underframes. These show four different combinations. One example is of a double-acting buffer set; another pattern is the Railway Clearing House type, in which the draw-bar rubber springs are arranged in two groups in line in a cradle. Another is the standard Indian pattern in which the draw-bar springs are double, being placed side by side. A fourth is an arrangement for the South African Railways, which employ the central buffer coupler, and in which therefore the buffing and draw-bar springing is combined on the draw-bar rigging. The firm's vacuum hose is also conspicuous at the stand. A novelty is shown in the form of a railway wheel with rubber-supported steel tyre. This we have briefly referred to above, a section of the arrangement being given in connection with our description of the Sentinel-Cammell coach to which it is fitted. Fig. 65, page 7, shows a driving wheel. The trailers are similar as regards the wheel centre, but are without the sprocket drum bolted on. In this wheel the centre is finished with a projecting flange on the inner side, drilled with a number of bolt holes. The centre is turned a good deal smaller than the bore of the tyre, and between the two are inserted a number of rubber blocks. A retaining ring is fitted to the outside and fastened to the centre by bolts passing through the rubber blocks and inner flange of the centre. The inner flange overlaps the tyre, which is recessed. The process of tightening up the bolts compresses the rubber and causes it to be pressed out in radial and circumferential directions so as completely to fill the space between the centre and the tyre. The wheels themselves are made by Messrs. Cammell Laird, the rubber blocks being of Messrs. Spencer, Moulton's manufacture.

In our issue of April 25 (page 535 of our last volume), we referred to the first-class control trailer being shown at the Exhibition by the Metropolitan Railway. The coach has been constructed for the railway by the Metropolitan Carriage, Wagon and Finance Company, Limited, and is representative of the latest type of coaching stock in use on that line. By the courtesy of the railway company and of the builders, we are able in Plates IV and V to reproduce in Figs. 73 to 81 drawings and photographs of this suburban stock. Of our illustrations Figs. 73 and 75, Plate IV, give side and end elevations of the coach, Fig. 74 an interior plan, and Fig. 76 a cross-section through the non-smoking compartment; Fig. 78 is a plan of the underframe and Fig. 77 one of the bogie. A general outside view of the coach is given in Fig. 79, Plate V, while Figs. 80 and 81 are interior views respectively of the smoking and non-smoking compartments.

The coach seats 45 passengers in the two compartments, while at one end is the driver's compartment containing the controls. Normally, the latter are enclosed in a collapsible casing, and the vestibule then serves as an additional exit for passengers. Three large double doors are provided on each side of the car for the passenger compartments. The car is 50 ft. 10 in. over headstocks, 51 ft. 6 in., over body pillars, and 52 ft. 6 in. over all (coupled). The wheels are 3 ft. in dia. on tread. The bogie wheel base is 7 ft., the bogies being centred 35 ft. apart. The width of the body is 8 ft. 9 in., and the height from rail to top of roof 12 ft.

The underframe is of steel channel, the sole bars, headstocks, longitudinals and main cross bearers being 9 in. by 2½ in. section. A 1½-in. truss rod is provided under each sole bar, extending over the main cross bearers out to the headstocks. The upper side of the frame is plated all over with 6-lb. steel plate, riveted to all members, thus safeguarding against deformation, and furnishing a good foundation for the cement flooring. The bogie bolsters are double 9-in. by 3-in. channels carried at each end on two helical springs, and are fitted with strong centre castings and with side bearings. The bogie side frames, transoms and headstocks are of pressed steel ⅜-in. plate. Renewable cast-iron horn blocks are fitted to cast-steel horn plates. The bolster is built up of two 9-in. by 3-in. channels, plated with ¼-in. plate at the top and bottom. The spring plank is a 12-in. channel. It is supported by knife-edged bearings hung from swing links of the adjustable eye-bolt type, swung from the transoms. Excessive movement sideways is checked by 1¼-in. rubber blocks on the side frames, allowing free movement of ¾-in. to either side. The side springs are laminated and semi-elliptical, 4 ft. 3 in. between centres. The spring hangers have auxiliary rubber cushions. The wheels are of Messrs. Taylor Brothers, Limited, rolled steel disc type, with tyres shrunk on and held by a retaining ring. The tyres are of 50-55 ton tensile steel and the discs of 28-35 ton steel.

In the bodywork lightness and strength have been combined in light pillars well supported by horizontal members, stiffening being obtained by means of outside panels of No. 17 S.W.G., below the waist rail. The framing is entirely of teak. The continuous cant rail is 4 in. by 3 in., and the pillars are framed together by four horizontals above the waist and two below the waist, in addition to the usual fence and belt rails and plinth. The latter consists of a steel plate screwed down on two light rails inside the body. Above the waist the panels are of teak. Pillars are tenoned into the cant rail and bottom side rails. The latter are stopped at the doorways. The pillars are strengthened by steel knees at the top and bottom. A 2-in. by ⅜-in. steel bracing passes over the centre doorway of each side, and extends diagonally down to a pressed-steel bracket fixed to the bottom side-rail below the adjacent windows. An additional diagonal brace is taken up from this bracket to the waist at the next quarter. The rear end is square, with five pillars, arch rail and intermediate cross rails. This end of the body is entirely plated outside with No. 17 S.W.G. steel panel sheeting. The driving end of the coach tapers forward as shown in the plan Fig. 74. The bottom rail is a single teak member 10½ in. wide. This end is also steel panelled except as regards the window openings. The roof is constructed of light ash hoopsticks screwed to steel carlines of 2-in. by 1-in. by ¼-in. channels, the flanges of which are turned back to form a foot on the cant rail. The outer and inner roof sheeting is of ⅛ in. and ⅜ in. thickness respectively, of yellow pine, tongued and grooved.

The windows are framed in teak. The side windows are fixed and surmounted by two movable glass frames, hinged at the lower edges. The front lights are arranged to drop. The side and vestibule doors are of teak, the partition doors being of the same wood. The door at one side of the vestibule has a drop light, so that the driver may take the guard's signal without opening the door. The side sliding doors act together, being coupled by chain and sprockets. They are hung on ball bearing runner bars, and slide back into pockets of steel sheeting. The partition and draught screens are also of teak, and the whole interior finish is in the same material. The usual advertisement spaces are replaced by polished teak panels; the quarter panels between the windows are finished with inlaid ebony and satin wood.

The seats are grouped so as to allow of large, unobstructed standing spaces. The smoking compartment seats are upholstered in dark green, embossed buffalo hide, the non-smoking compartment being treated with blue and grey moquette of floral design. Fixed arm rests are provided between the longitudinal seats. The ceiling is ¼-in. asbestos millboard laid on the inner roof sheeting. It is finished with flat white enamel. The lamp fittings are of oxidised gunmetal, this material being used for all interior fittings, hand grips, &c. Strap hangers are not used. The floor is laid with Docker's induroleum, ⅛-in. thick, this composition being used on all the company's stock.

The coach is fitted with the Westinghouse quick-acting brake, using a 10-in. short-stroke cylinder fitted with automatic slack adjuster. A 3½-in. triple valve, dust catcher, emergency and isolating valve, with usual reservoir and connections, are arranged as on the company's usual stock. In addition, at the driving end are a driver's brake valve, whistle, duplex gauge, isolating cocks, &c. The handwheel for hand brake is also in this compartment, as shown in the plan, Fig. 74, the underframe plan, Fig. 78, indicating the position of the bevels through which the power is applied to the brake rigging. The hand and power brakes act independently on all wheels, with two blocks for each wheel. The buffing and draw gear consists of a combination of buffing fender and central automatic coupler. The fender is a steel pressing 3 ft. wide, supported by two plungers working in cast-steel guides. It acts against two Spencer-Moulton rubber springs having a maximum range of 5½ in., of which 2½ in. are taken by initial compression, and a further 1½ in. when the cars are coupled. The coupler is a small type of the M.C.B. pattern. When buffing, it compresses two sets of rubber springs in parallel with ⅞-in. initial compression and 2⅜-in. stroke. When pulling, the strain comes on a steel helical spring in compression, with an effective stroke of 1½ in. The tight-coupling now adopted has resulted in much-improved riding qualities. The short overhang brings the coaches close up to one another, the space between them being only 10 in.

The lamps consist of two in the vestibule and 24 in the compartments, all of 16 c.p., four additional lamps being placed down the centre of the car. Eighteen Simplex electric heaters are placed beneath the seats, the latter being protected by asbestos sheet. The heaters consist of non-oxidising nichrome wire coiled on a porcelain bobbin. The winding is for 100 volts, and six heaters are wired in series on a 600-volt circuit, with a safety margin for 10 per cent. excess voltage. The consumption per heater is 3·6 amps., the loading under full voltage being therefore 360 watts. The switchboards are fitted on the rear screen. The power equipment in the driving compartment merely consists of the master controller and switches, fuses, connection-boxes, &c. The Metropolitan-Vickers Electrical Company, Limited, was responsible for all the electrical equipment.

At the stand of Messrs. Tyer and Company, Limited, of Dalston, engineers will find a large selection of this firm's well-known patterns of signalling instruments and other apparatus. The whole exhibit is characterised by the excellent workmanship and finish which has always been a feature of Messrs. Tyer's products; their long experience has convinced them that well-finished apparatus inspires increased care on the part of the user.

One exhibit of interest shows the application of roller bearings to ground connections, such as cranks, compensators, &c. Messrs. Tyer, after experimenting extensively in the use of ball bearings for these fittings, have decided on standardising roller cage bearings, these being found to have a number of advantages. The rollers are carried in a cage which ensures correct spacing, at the same time allowing a slight amount of play at the commencement of a movement. With the cage the rollers are all kept together and none need be lost. The cage is placed over the pin after all fitting work has been completed on the ground, and as this is the final operation cleanliness may be easily assured. A brass washer prevents dirt working upwards from below, while a mushroom shaped cover protects the grease cup and the whole bearing against both dirt and wet. The application of such bearings increases the cost of lay-out of a large yard by only a small percentage (1½ to 3 per cent.), but the maintenance costs are greatly reduced and the parts benefit to the extent of a longer life. At the same time the effort needed on the part of the operator is much reduced, while points and locking bars can be satisfactorily worked from much greater distances than with the ordinary plain bearing.

A short reference may also be made to Messrs. Tyer's "Signalite" long burning oil signal lamp. This has been known for some time as also has the simple adjustable bracket on which it is fitted. The lamp will burn for 200 hours, and, for cases where the post is situated out of sight of the operator, is fitted with a thermostat repeating device,

which warns the signalman in case of failure by means of a repeating lamp, placed in the signal cabin. The thermostat consists of a disc, slotted radially, placed over the flame. Above the disc is arranged a T-piece, the two arms of which are pivotted in cups, while the tail is raised and lowered by the expansion and contraction of the centre of the disc under the influence of the flame. This movement of the tail causes contacts to be made or broken, thus controlling the repeating indicator or lamp in the cabin.

In connection with this firm's exhibit we would draw attention particularly to two new instruments, one being a one-wire three-indication block instrument, and the other a key-token instrument for single line working. We do not propose to enter upon a discussion of the safety of the one-wire system for block signalling. The system has been in use sufficiently long and on a scale to warrant confidence as complete as can be placed in any appliance devised for this work. Giving service as good as the three-wire system, the one-wire method certainly introduces a considerable degree of economy in capital outlay and upkeep, and therefore presents attractions of a very material character. The new one-wire three-indication instrument of Messrs. Tyer is illustrated in Figs. 82 and 83 above, and embodies important changes from former models, the mechanism being considerably simplified. In the new instrument the "Line blocked" position is placed centrally with "Train on line" to the left and "Line clear" to the right—thus conforming to general practice, instead of as formerly having the indications running (from left to right) in the order "Line blocked," "Train on line," and "Line clear." Another noticeable change is the elimination of the small side plunger which was formerly on the left of the commutator handle and was worked by the left hand, the commutator being worked by the right. In the present design the plunger is incorporated in the commutator handle itself. In Fig. 83, which shows the front casing removed and the bottom door swung back, the commutator will be seen on the door and the mechanical commutator lock will be noticed below. The commutator is provided with three notches in its rim, and cannot be moved from any one position to another until the plunger has been pressed and the signal recorded, when the commutator is freed. The commutator movement is extremely simple, and it can be used purely for block working, with the commutator free to turn in either direction (instead of formerly only in one), so that it can be moved from any one position to any other—or the movement can readily be converted into a sequence movement for "lock and block" working. In Fig. 83 above the commutator an electric lock is shown which is connected with a track circuit controlling the commutator when in the "Train on line" and "Line blocked" positions. With this control the commutator cannot be moved from "Train on line" to "Line blocked," or from "Line blocked" to "Line clear," unless the track is clear, but for blocking back purposes it can be moved from "Line blocked" to "Train on line." The arrangement can be modified to suit all conditions of "lock and block" working. With previous instruments, blocking back has not been possible.

The needles are operated by means of twin armatures, the needle movement being of a new design. It is self-contained and in each case can be entirely removed by taking out four screws, which hold it to the steel cores of the electro-magnetising combination. The dial can be entirely removed without affecting the adjustment of the needles, and inspection can therefore be much more easily carried out than in previous patterns. Only one battery is used with this system and currents flow only when the instrument is worked. Full strong currents are sent to the line for "Train on line" and "Line clear," and weak currents for "Line blocked." Switching out is provided for by winding the coils to a resistance which will permit the instruments to work satisfactorily through a line resistance up to 200 ohms, thus rendering the introduction of balancing unnecessary.

The Key Token instrument recently introduced by Messrs. Tyer is shown in Figs. 84 and 85 on page 11, the latter, illustrating the instrument with casing removed, shows the chief portion of the mechanism which is a commutator operated by the key token. The key is inserted into and removed from an aperture in the centre of the upper part of the instrument. From this aperture a four-slot magazine is branched for the storage of the tokens in use on the section. Only one token can be out of the instrument at a time. The signalling bell plunger is on the right of the face; the bell itself is generally fixed apart from the instrument, but can be fixed inside the casing where considered desirable. On the left of the face is a train indicating handle worked by the signalman during the operation of signalling, but electrical indications can be arranged to replace this part if so required. The only moving part is the commutator and the makers claim this instrument as the simplest, and as containing the minimum of parts, for efficient working. The commutator is controlled by an electric lock. In the latest pattern this consists of a polarised lock which dispenses with the need for the relay formerly employed, thus tending still further to simplification. No permanent currents are required, and the battery power needed is small. A magneto may be used instead of the usual batteries, in which case the signalling plungers for the two instruments in a box would for convenience be fitted to the magneto, placed between the two instruments. A token can be restored to the instrument from which it has been withdrawn in the event of a train being cancelled, or after having been used for shunting purposes. For permissive working, where allowed, a certain number of tokens can be made in three parts to enable this form of operating to be adopted. The instrument shown is identical with the pattern used on the Great Western Railway for single line working. Siding point locks worked by key tokens are also made, while the instruments can also be arranged for operation by the guard or driver of a train. The instrument, in the latter system, can be used for sections with three or more stations. Two line wires are then necessary, with electrical indication.

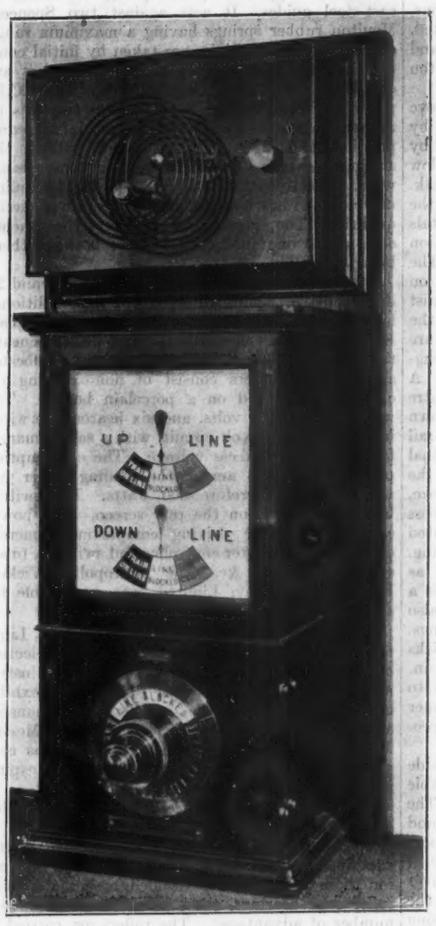


FIG. 82.

FIG. 83.

FIGS. 82 AND 83. ONE-WIRE THREE-INDICATION BLOCK INSTRUMENT; MESSRS. TYER AND CO., LIMITED.

RAILWAY MATERIAL AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 6.)

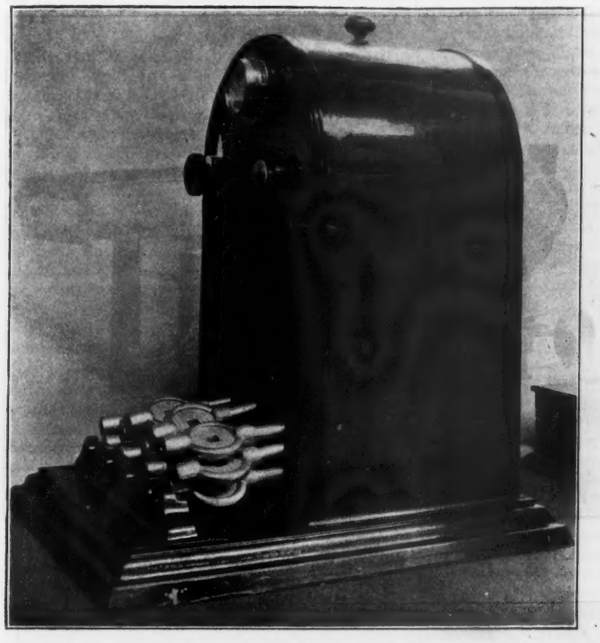


FIG. 84.

FIG. 85.

FIGS. 84 AND 85. KEY TOKEN INSTRUMENT FOR SINGLE LINE WORKING; MESSRS. TYER AND CO., LIMITED.

THE MACHINERY OF THE COTTON MILL AT THE BRITISH EMPIRE EXHIBITION.

THE most representative display of modern textile machinery that ever has been shown at any exhibition is provided in the Cotton Mill in the Palace of Industry of the British Empire Exhibition. The exhibit is a co-operative one which was organised by the Cotton Textile Industry Committee, and thus each firm, though they may make textile machinery for every process used in the industry, is represented by some few items only. It must not therefore be taken that the types of machines exhibited are the only ones for which the individual firm exhibiting them, has earned a good reputation, or that any particular type of machine is only made by the firm whose machine is shown. As the machines are shown in actual work, this exhibit affords an opportunity of describing the nature of the processes and their importance in the industry, as well as the modern machinery methods by which they are performed.

All the textile industries of our country depend largely, if not entirely, on imported raw materials. Most of the raw cotton used in Britian comes from the Southern States of America. The next largest supplier is Egypt, from which country quantities of fine cotton are obtained. Growth is possible, however, in many other lands, and some success has already been attained within the British Empire. The Northern Territory of Australia, Queensland, British Guiana, the West Indies, Sierra Leone, the Gold Coast, Nigeria, parts of the Union of South Africa, and the African Colonies, India and Burma are all within the equatorial belt within which cotton could be grown to commercial advantage on suitable land. Already large quantities are produced in India. Great achievements are anticipated from Gezira, a tract of land of 3,000,000 acres in the Sudan between the Blue Nile and the White Nile. The scheme for irrigating this land is being actively pressed forward at present. Cotton growing is making steady progress in Uganda, Nigeria and the Tanganyika Territory, while a certain amount of success has been already obtained in Australia, South Africa, Nyasaland, the West Indies, Mesopotamia, Kenya and Rhodesia. The provision of great irrigation schemes and improved transport facilities will do much to make economical production and distribution possible, and thus will naturally lead to increased areas being put under cultivation.

The first operations on cotton take place at the place of growth. After the plant has flowered, the seed case bursts and the cotton appears. This is plucked away and is taken to the ginning factory, where the cotton fibres are separated from the seed. In this process the success is to be measured by the freedom from injury to the fibres. Some fibres break up before they can be separated from connection with the seed, while others carry with them a portion of their husk. Examples of plant used for the purpose are shown in Figs. 1 to 5 on Plate VI. The first machine is an example of a hand power machine in which the features of what is known as the Macarthy roller are embodied. The cotton is fed on to the top table and falls into a hopper, where it is brought into contact with a roller by the action of a reciprocating feeder bar. A doctor knife is pressed against the roller by means of springs. The fibres adhere to the roller, and the seeds remain at the point of contact between the doctor knife and the roller, being separated from the fibre. The shaft at the foot of the machine is provided with a small crank which operates a connecting rod to which is attached a beater blade beside the roller. Rapid reciprocation is therefore given to the beater blade, and the sharp blows detach the seed from the fibres. The seeds fall upon a grid and are taken away. The beater blade is guided in its path by connection with the bars shown below the projecting part of the table of the machine. By means of these rods, which are screwed and provided with adjusting nuts, regulation of the distance of the blade from the roller to suit the size of seed is possible. From the roller the fibres are removed by a stripping board, and they fall to the floor.

A single action, single roller mechanically-driven Macarthy cotton gin is shown in Fig. 2. In this machine an automatic feeder is fitted and makes possible the supervision of a number of machines by a single operator. A spiked lattice lifts the material from the hopper and distributes it uniformly across the whole length of the ginning roller. Any surplus seed cotton is returned back into the hopper without the infliction of damage to the seeds. This machine is eminently suitable for all the long stapled varieties of cotton, such as Egyptian, Sea Islands, and many of the American types.

Almost every description of wooly seed cotton can be treated in the machine illustrated in Fig. 3, which is a double action, single roller type of Macarthy gin. In it the double beat of the knives for each revolution of the driving shaft assists materially the separation of the fibre from the seed without injury to either. Each knife is balanced against the other and consequently an easy and steady motion is obtained throughout the period that the machine is in use. The automatic feeding device referred to in connection with the single action type may also be applied to this gin.

Another process used in ginning cotton is what is known as "sawing." A hand machine of this type is shown in Fig. 4, while a power type is illustrated in Fig. 5. In these machines the seed cotton is fed upon a moving lattice, from which it is removed by a spiked roller and is thereby loosened. It is then thrown so that it falls into a hopper, where it comes into contact with a series of rapidly revolving saws. In the hand-working machine (Fig. 4) there are 16 of these, while in the power machine (Fig. 5) there are no less than 40. As the saws revolve the fibres get caught in the teeth while the seeds cannot follow them in their movement because they are restrained from doing so by a series of bars beside the saws. A revolving brush removes the fibres from the saws, and they are carried away in an air current. The hand gin shown gives a production of 22 to 24 pounds of cotton per hour, while the power machine has an output of cleaned cotton which varies with the type of cotton used up to a maximum of about 200 lb. per hour. All the gins illustrated in Figs. 1 to 5 are the products of Messrs. Platt Brothers and Company, Limited, of Hartford Works, Oldham.

The cleaned cotton is next taken to hydraulic

MACHINES IN THE COTTON MILL AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. PLATT BROTHERS AND CO., LIMITED, ENGINEERS, OLDHAM.

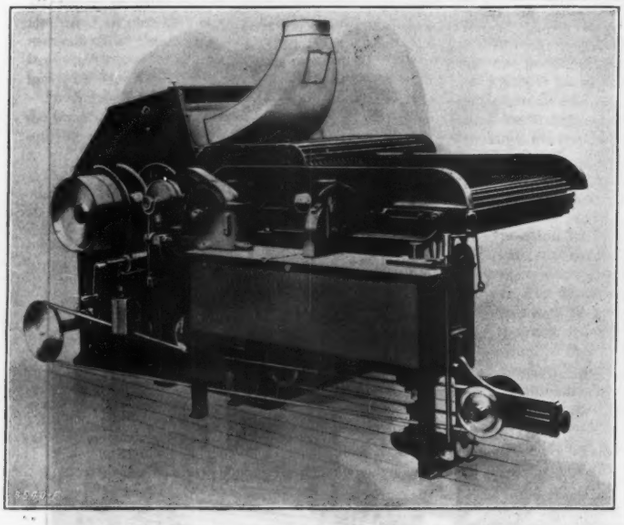


FIG. 10. LATTICE FEEDING MACHINE.

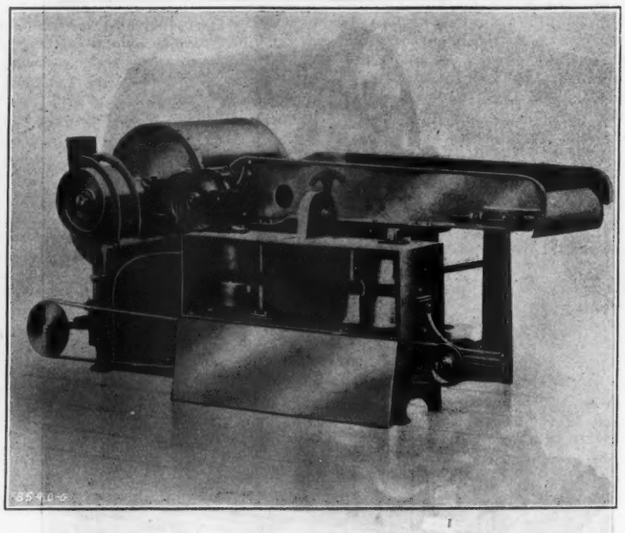


FIG. 11. ROVING WASTE OPENING MACHINE.

presses, where it is compressed to very small bulk and is then shipped for use in the mills. The development of the production of cotton cloth from this raw material has reached its highest state in Lancashire, but it must not be forgotten that the industry has now spread over almost the entire world. The industry has been subject to an evolutionary growth in which the development from primitive beginnings to its present state is a subject of interesting and fascinating study. It is not, however, our intention to embark on any treatment of it or to apportion praise to individual inventors for their contributions to the great development, but rather to review the present-day practice in the production of cotton textiles as shown by the exceptional display of plant in the Cotton Mill of the Palace of Industry. The importance of the industry to Great Britain must not, however, be lost sight of, because the production is about four times as much as the home consumption. Large exportation takes place, and thus important contributions are made by the industry towards the maintenance of our international trade balance. In 1923, a year of depression, the exportation of cotton yarns amounted to over 21,000,000*l.* in value and of cotton cloth to over 138,000,000*l.* The industry also is important in that it provides employment for a large proportion of the workpeople in the densely populated district surrounding Manchester, within a radius of 50 miles of which, the area embracing the cotton mill region, more than one-sixth of the total population of Great Britain is concentrated.

When the cotton bales are received in this country they must first be broken. Fig. 6 shows a machine made by Messrs. Platt Brothers and Co., Limited, for this purpose. The action of this machine is such that when the cotton taken from the bales in large pieces is placed into the hopper, a horizontal lattice carries it forward and presses it against the spikes of an inclined elevating lattice, where it is subjected to a combing action. It is then carried upwards to a spiked roller, which gives it a further combing and throws back into the hopper any large or unopened pieces. The spiked roller is stripped and kept clean by a stripping roller, the surplus again falling back into the hopper. A beater removes the cotton from the inclined lattice, while it falls upon a grid which conveys it to the opening plant. This is used to remove from the cotton a large proportion of the residue of the foreign matter it contains and to open out the cotton in the process to assist its release. The opening and cleaning process is a delicate one, whether the cotton is treated so as to allow the undesirable material simply to fall, or to be thrown away from the fibres by the use of centrifugal force. Trusting to the attention of a worker is associated with heavy costs and rather indifferent work, and has led to the development of machine operations by which the cotton is fed in and acted upon in such a way as reduce the possibility of damage to the fibres to a minimum. The opening plant takes many forms, each suitable for the treatment of particular grades of material, and examples are to be seen in the machines illustrated in Figs. 6 to 9 on Plate VI, and in Figs. 10 to 12 above, while Fig. 13 shows what is termed a scutcher, in which the cleaning operations are further continued by a process of beating or whipping.

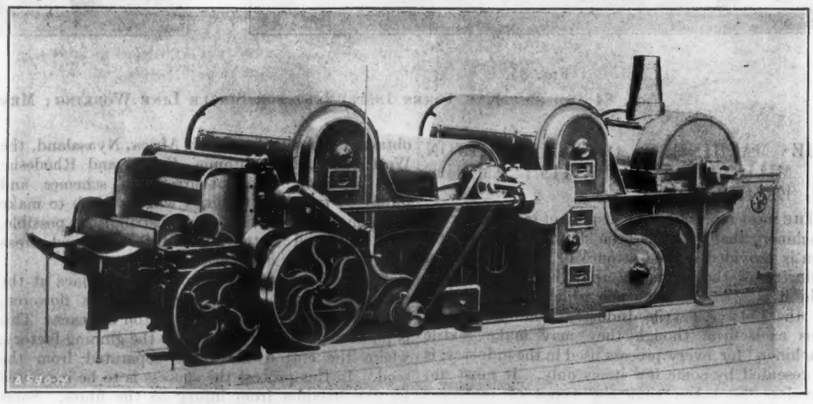


FIG. 12. EXHAUST OPENER LAP MACHINE.

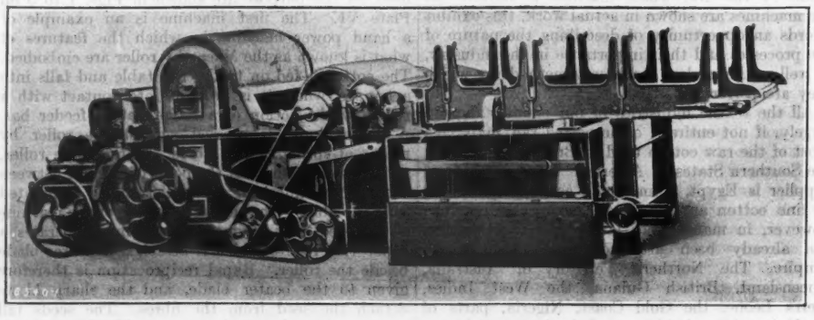


FIG. 13. SCUTCHER AND LAP MACHINE.

A hopper opener of the Platt and Wilkinson type

is shown in Fig. 7. This was specially designed for the opening of cotton from hard-pressed bales by means of the combined action of very strong spiked and evener lattices. Its essential feature is to control automatically the delivery of cotton from the bale-breaker to the hopper-feeder. This hopper opener, Fig. 7, has two weighted and balanced spring doors. These automatically regulate the delivery of cotton by their opening through a connecting rod which is worked from the belt-shifting arrangement of fast-and-loose pulley on the bale breaker, with which it is associated. The value of the combing action by the use of spiked lattices is in the opening of matted fibres of cotton without damage and without curling the fibres. In this open condition sand, seeds, husks, and other matter are free to drop through several grids over which the cotton passes on its way to the exhaust opener. An automatic hopper-feeding machine is shown in Fig. 8. In this the height and density of the cotton in the hopper is most effectively controlled by an automatic filling apparatus, and the opening action upon the cotton is obtained by the action of fine pins on the lifting and evener lattice.

A machine known as the Crighton opener is shown in Fig. 9. This machine has been for long established as one of great value in the cleaning of most classes of cotton. It is commonly worked in connection with a hopper feeder, but in some cases is worked with the bale opener for treating low grade cotton before mixing. The opening action is obtained by the use of a number of steel discs of small diameter at the foot and of increasing size towards the top. They are all mounted on the same vertical shaft, which is supported on a ball-bearing footstep. On the discs are riveted a number of knife blades. The cotton is passed in at the foot of the revolving system, and as it is loosened by contact with the blades the opened cotton is carried upwards by an air current towards the next larger disc. Here again further opening actions result, and the process is continued right through the machine, when the resulting cotton is free from the foreign matter it originally contained. The grids surrounding the revolving system contain a great number of holes, which are shaped so that the dirt thrown through them falls outside and is not liable to be drawn again into the machine. A guide pulley system ensures that the rope drive is effective in causing the revolution of the vertical spindle without any tendency to leave the main pulley.

The lattice feeding machine shown in Fig. 10, on page 12, is of the Platt and Wilkinson type, and is used in connection with the various opening and cleaning machines. In this machine the feed rollers and delivery trunk are both on one side of the machine. The example shown has a cylinder of 24-in. diameter provided with strong combing blades. An improvement is to be noted in the grid construction of the machine, as the old arrangement of having them extended to about one-quarter of the circumference of the cylinder has been replaced by a new type which covers about three-quarters of the cylinder. Spacing blocks and grid bar circles are also introduced to allow easy setting of the grids. When used with a bale breaker and Crighton opener this lattice feeding machine is used for cleaning purposes only, but when fitted in association with an exhaust opener lap machine, of which a description will be given later on in this article, it is fitted with a regulator which ensures the passage from it of an even sheet of lap cotton.

Great economies may be effected in mill working if all soft waste can be treated to put it in open fleecy condition to permit it being mixed with raw cotton and with it be converted into yarn. A machine such as makes possible the opening of waste is shown in Fig. 11, which actually illustrates a roving waste opening machine made by Messrs. Platt Brothers and Co., Limited. This machine has a 24-in. diameter spiked lag cylinder on roller bearings. The waste is placed on a lattice and is carried forward to the feed roller and is then subjected to the treating action given by the spiked cylinder, and, after beating, is finally passed out of the machine. In a general combination of machines it may be connected to an exhaust opener by means of a pipe, so that an even amount of opened waste may be passed out regularly blended with the opened cotton.

Fig. 12 shows an exhaust opener lap machine with Platt and Wilkinson's inlet to exhaust cylinder. The exhaust cylinder of this machine is used to furnish the suction for the cotton through a lattice feeder machine, a Crighton cylinder and dust trunk. The exhaust cylinder in conjunction with the cage fan delivers the cotton in a level fleece on the cages. From here it passes through between feed rollers, from which it is acted upon by a bladed beater or combed by a striker cylinder to take out the remaining impurities, after which it is passed between the lap end cages to the calendar rolls, where it is formed into a firm level lap roll. When first set to work the lap sheet may be found to be thicker at the one side than at the other. To correct the working, adjustment is possible, as the inlet to the exhaust cylinder can be moved to any extent up to 2½ in. out of centre, to either side of the machine, for the purpose. The capacity of the machine shown is between 500 lb. to 700 lb. per hour, according to the type of cotton in use.

The scutcher is a machine in which generally four laps from the opener are placed upon the feed part, and are formed into regular even laps for carding. As the production of this type of machine is only about one-half of that of the opener, and sometimes less, the regulating roller is always worked at a very slow speed, which permits any irregularity of the four laps passing under it to be easily compensated for by the regulating motion moving a pair of coned drums on which the belt runs. Each lap taken from the finishing scutcher is weighed, and only a small variation is permitted. In place of a bladed type of beater the machine shown in Fig. 13 has a striker cylinder of 18 in. diameter arranged on roller bearings.

(To be continued.)

B.T.H. AUTOMATIC SUB-STATION EQUIPMENT AT THE BRITISH EMPIRE EXHIBITION.

FROM the point of view of the number of firms which display it, switchgear may be looked upon as one of the most important types of exhibit in the electrical class at the British Empire Exhibition. Much progress has been made in its design in recent years, and a very important new field has been entered by the development of gear for the automatic control of sub-stations. The Exhibition forms, we think, the first occasion on which an extensive display of such gear by various makers has been brought together in this country. Among the important gears of this class, which have been applied to a very considerable extent in practice, that manufactured by the British Thomson-Houston Company, Limited, of Rugby, takes a high place. A sub-station fitted with this gear may be left quite unattended, no matter what the operating conditions, the gear automatically controlling the starting up and shutting down of the rotary plant. Full protection is afforded, and the control is not only equal to, but is better than, that afforded by skilled attendance.

Experience up to the present is that there are no operating conditions which cannot satisfactorily be dealt with by automatic gear, and arrangements may, for instance, be made so that the machines in an automatic sub-station are started up when the load demand reaches a pre-determined value, or when a manually-operated master control switch is closed in some distant control room. The machines may also be started up by a time-switch or by the closing of a high-tension feeder switch at the power station, or some other point. When there are two automatic units in one station, the first may be started up by any of these methods and the second then brought into service when the load becomes too great for the first, while the gear can be arranged so that the inspector on his periodic visits to the station can change over the order in which the machines start up, so that the total running time is fairly distributed between the units. Triple unit installations may be arranged on similar lines.

The advantages of automatic sub-stations are many. As there is no continuous attendance, a simple type of building is all that is necessary, and not only are labour charges eliminated, but also various incidental expenses, as, for instance, those for lighting and fuel. It is, however, probably in connection with direct-current distribution costs that the greatest savings lie. Inexpensive sub-stations requiring no attendance can be placed at various load centres in such a way that very important savings in low-tension feeders may be made, and it will usually be found that the copper saving considerably outweighs the cost of the automatic gear. This application of automatic sub-stations will frequently allow of over-loaded distribution networks being relieved and made capable of carrying increased loads, without any further expenditure on distribution cables, by placing automatic sub-stations at new feeding points.

The type of control which is arranged for with automatic sub-station gear varies with the type of service which is being given, and, for instance, on traction service, when it is not generally required to keep the direct-current voltage within such close limits as are necessary for lighting systems, it is usual to arrange, with rotary converters, for manual setting of the field rheostat. This is arranged to give normal voltage on to machine and is left permanently in the position in which it has been set by hand. The rotary, being compound wound, keeps up the voltage when the load comes on, and is under load control only. With motor generators on traction service load control only is also usually sufficient, but when desirable, as is sometimes the case on high voltage direct-current installations, voltage control may also be employed. For general lighting and power service the addition of voltage control is usually essential, and a motor-operated field rheostat is incorporated in the equipment.

The automatic control schemes necessarily involve a number of relays, contactors, &c., and dealing with the whole question in a broad way it is not necessary nor desirable to give a complete enumeration and description of all the items of equipment involved. A general idea of the working of the systems may be given and understood without any recourse to diagrams of connections or minute descriptions of relays. Load control only, which is generally all that is necessary for traction stations, is the simplest arrangement and may be dealt with first. We may consider a compound-wound rotary converter station as a characteristic example. The necessary gear in the station, in addition to the machine itself, consists of a transformer and high and low tension switchgear, the high-tension gear comprising an oil circuit-breaker and control transformer for supplying alternating current for the control circuits, and the low-tension gear covering an alternating current starting and running panel, a relay panel and a direct-current control panel. Sequence of operations is controlled by a motor-driven master controller which is a robust mechanical device and eliminates any necessity for numerous interlocking contacts on the contactors.

The automatically controlled rotary is started up as soon as the demand for power reaches a predetermined value, which is indicated by the fall in the direct-current line voltage. This voltage operates a master starting element which closes its contact and energises a master control contactor through a time-element relay. The purpose of this relay is to prevent the equipment starting-up due to momentary fluctuations of line voltage. The closing of the master control contactor causes the motor-operated controller to rotate, thereby closing the high-tension oil circuit-breaker and energising the main power transformer. Further rotation of the controller closes the starting contactor, and at the same time connects an auxiliary field winding on the rotary converter to an auxiliary generator which is driven from the rotary converter shaft. The starting contactor then energises the starting motor and the machine starts. At this point the controller stops and waits for the machine to synchronise.

As the rotary converter accelerates the auxiliary generator builds up its voltage, thus energising the auxiliary field winding and fixing the polarity of the machine. When the voltage of the generator attains approximately 80 per cent. of normal it causes a synchronising field contactor to close and adjust the resistance in the main field of the rotary converter to the correct value for synchronising. When synchronism is reached a synchronous-speed indicating relay operates and re-starts the master controller, thus closing the running contactor and connecting the machine direct to the transformer, while the field strength of the rotary converter is adjusted to the correct value for paralleling by the closing of the full field contactor. This is followed by the opening of the starting contactor. This latter it will be noticed does not break circuit with current flowing. It is only called upon to make circuit under these conditions. At the same time as the starting contactor opens, the auxiliary field winding is disconnected from the auxiliary generator and the machine is ready for connecting to the direct current busbar. The master controller continuing its travel then closes the machine high-speed circuit breaker and then the line contactor, thus connecting the rotary converter to the busbar. The master controller then comes to rest in the running position in which it remains until the machine is shut down. The rotary converter

then continues to run and supplies power until it is shut down by an underload or by the operation of one of the protective devices.

When the load on the machine falls to a predetermined value an underload relay operates and energises a time-delay stop relay. The time-delay feature is incorporated to prevent a shut-down due to momentary fluctuations of load. When the time delay of the relay has expired the relay operates and interrupts the coil circuit of the master control contactor, thus causing it to open. This in turn causes the immediate disconnection of the machine from the direct current busbars by interrupting the coil circuit of the high-speed circuit breaker and line contactor. A normally closed contact on the master control contactor provides a circuit to ensure that the master controller is immediately rotated to the off position. As this controller rotates to the off position it interrupts the coil circuit of the running contactor, thus disconnecting the machine from the power transformer, it also completes the trip coil circuit of the high-tension oil circuit-breaker, which trips, thereby disconnecting the power transformer from the main supply. The master controller finally comes to rest in the off position, and the equipment is then ready to re-start when required. Although these operations of starting up and closing down sound complicated in detail description they are actually quite straightforward and occupy but a very short time. The equipment will start up and put a rotary converter on load in a period varying from 30 to 45 seconds depending on the characteristics of the machine.

Some characteristic examples of this automatic substation gear are illustrated on Plate VII and page 16, Fig. 1 on Plate VII showing a simple rotary converter with the starting and running panel fixed in front of the oil-cooled power transformer. The high-tension oil switch cubicle can be seen on the far side of the transformer. The starting motor for the machine and the auxiliary generator, driven from the rotary shaft, which energises the auxiliary field winding can clearly be seen in the figure. The second example, illustrated in Fig. 2, shows the automatic gear for a railway sub-station containing two 1,200 kw. 600-630 volt self-synchronising rotary converters. The relay control panels can be seen in the foreground and beyond them a panel for controlling four feeders.

This automatic gear is fully provided with control and protective devices. Of these one of the most important is the high-speed circuit breaker two views of which are given in Figs. 3 and 4 on page 16. Fig. 3 shows the breaker in normal operating position, but with one of the arc shields removed to expose the horn break. Fig. 4 shows the way in which the arc shields may be lifted for inspection of the contents. This breaker has already been referred to in connection with the normal operation of starting-up or shutting down. When excessive overload occurs this high-speed breaker opens and inserts a limiting resistance in the machine circuit, while by means of an electrical interlock on the breaker the live contactor is opened and disconnects the machine from the busbars. After a short time interval the breaker re-closes, and if the trouble has disappeared remains closed. If, however, the overload persists the breaker again trips, reclosing as before after a time interval. The breaker is controlled by a repeat action relay which can be set for any number of "notches" from one to six. The relay takes a notch for each time the breaker opens and is provided with a timing device. Should the breaker remain closed for a period equal to the time setting the notches are reclaimed, but if the breaker continues to open without notches being reclaimed the relay, on taking its last notch, operates its contacts and locks the breaker open until the trouble has been investigated and the relay re-set by hand. These breakers with their attendant relays are used for the protection of feeders as well as for machines, and such an application is illustrated in Fig. 5, which shows a board of four automatic 2,000-amp. 600-630-volt feeder panels in a railway sub-station. These high-speed breakers are usually mounted on a gallery well away from the other gear, as in this example. When feeders are fitted with this gear it is usual to set the relays for three notches and the corresponding relay on the machine panel for four notches, so that, after three attempts to close, a faulty feeder is permanently locked out and the machine can continue to supply the remaining sound feeders.

It will not be necessary to attempt to describe in any detail the remaining protective devices which are incorporated in the gear, but brief reference should be made to them. Overspeed of the rotary is looked after by an overspeed device which shuts it down and locks it out of commission until it is inspected. A low-voltage relay prevents the machine starting if the A.C. voltage is too low, and the same relay shuts it down should the voltage fail during running. The relay, however, re-sets itself and allows the machine to start when the voltage is restored. The machine is also prevented from starting unless all three phases of the high-tension supply are energised, this protection being obtained by a single-phase starting protective relay. In the event of stalling by the automatic control failing to connect the machine to the D.C. bars in a predetermined time, the rotary is shut down and locked out pending investigation. A temperature relay, with the same heating and cooling characteristics, as the machine, shuts down when the temperature of the machine has, owing to a sustained overload, risen to a predetermined value. The relay allows the machine to start when the latter is sufficiently cooled. Further temperature relays shut down the machine in the event of the bearings becoming overheated. Loss of supply for the D.C. control circuits and D.C. earth leakage are also protected against, as also are overheating of the starting motor, the flow of reverse power and overload or earth-leakage on the A.C. side. The machine cannot run with wrong polarity since it is provided with an auxiliary field winding which is separately excited from the auxiliary generator during starting. This winding is entirely disconnected from the auxiliary generator before the rotary is connected to the D.C. bars, and there is therefore no danger of the polarity of the generator being reversed by heavy fault reacting through the auxiliary field to the auxiliary generator.

The arrangements we have so far been dealing with concern rotary converters under load control only. Much the same arrangements apply to motor-generators, and it is not necessary to deal with them specifically. Similarly, when machines are under both load control and voltage control, the load control gear is much as described above. Extra gear is, however, required for the voltage control. This consists essentially of a motor-operated field rheostat with appropriate relays. During the process of starting the rheostat moves to the "all-in" position, and as the controller, the action of which was described earlier, reaches the running position, a voltage equalising relay causes the field rheostat arm to rotate from the "all-resistance-in" position until the voltage of the machine is equal to, or slightly greater than, that of the line. The relay then operates and closes an auxiliary contactor, which permits the line contactors to close. When the machine is connected to the line, a voltage regulating relay controls the voltage.

LETTERS TO THE EDITOR.

"THE TRANSVERTER."

TO THE EDITOR OF ENGINEERING.

SIR,—In the interests of A.C. Transmission, I really think I cannot let Mr. Highfield's first statement in his last letter to your paper pass unchallenged. No doubt every engineer will agree that, in the transmission line itself, particularly in the matter of underground cables, D.C. has distinct advantages over A.C., but when it comes to speaking of transmission in general terms the term is to be understood to include not only the line but the means for getting the required high-potential direct current for passing through that line; and until something equivalent to the static transformer, both in high efficiency, in low capital cost, and absence of demand for continuous attention in operation, has been found, and whose efficiency shall be within, say, 1 per cent. of the static transformer (this being about the difference in line losses between D.C. and A.C.) I feel justified in stating positively that it cannot be said that D.C. for transmission is better than A.C.

Mr. Highfield quotes the "overwhelming opinion of all engineers in favour of D.C. transmission," but he perhaps is not aware that within the next few days at least one engineer of considerable eminence will be found stating publicly what I have just said above, and I have no doubt, had I been on the lookout for same, a number of authorities could be mustered in favour of A.C. transmission equalling those supporting D.C.

The Transverter with its 5 per cent. higher losses (I include both "up" and "down") than the static transformer cannot possibly at present compete with same where transmission of current is concerned for utilisation as A.C. current at the receiving end.

I am, Sir, yours faithfully,
A. M. TAYLOR, Major S.O.2.

"Slade Lodge," Erdington, Birmingham, July 1, 1924.

CLEANING WATER MAINS.

TO THE EDITOR OF ENGINEERING.

SIR,—In an article which appeared in a recent issue of ENGINEERING (page 587 of your issue of May 2) describing apparatus for cleaning mains, it was said that the mains must either be cut or some other provision be made for getting the cleaning apparatus into and out of the mains. As it is an expensive job cutting pipes and making good again, it is often the custom, the article continued, to place hatch-boxes along the mains so that access may be had to the interior of the pipe.

This, of course, is correct so far as it applies to pipelines in general, but cutting and making good the pipes or the fitting of expensive hatch boxes is unnecessary on pipe lines fitted with Victaulic joints, as any one length of pipe may be removed and replaced quite easily without disturbing the rest of the line.

Even on a 36 in. main, a Victaulic joint takes less than 20 minutes to fit, and the removal of two joints, each with 4 nuts, means only 8 nuts to be removed as compared with the great number used for the cover of a hatch box, with the added advantage that the whole pipe-end is open for inspection. With lines not fitted with Victaulic joints throughout, these advantages may be gained by the use of an occasional length fitted with Victaulic joints.

In cases where it is not convenient to remove an ordinary length for cleaning or inspection, short lengths can be fitted.

Yours truly,
THE VICTAULIC COMPANY, LIMITED.
FRANK M. WRIGHT,
Manager C. I. Pipe Department.

28, Victoria-street, Westminster, June 25, 1924.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—So far as the engineering and heavy steel trades are concerned the new half-year has opened very quietly, and considerable improvement must be recorded if trading concerns are to unload the financial burden which they have assumed during the recent period of depression and emerge on a satisfactory basis. Railway and electrical enquiries hold out promise of big business if schemes under consideration in this and foreign countries mature, but at present the orders being booked are subject to the keenest possible prices, and though they provide a steadily expanding volume of work, the ratio of profit was rarely, if ever, lower. Makers of heavy machinery for steel works are carrying on steadily from month to month, though steelmakers and engineering concerns are unable to buy new plant as freely as they would wish, owing to the restricted resources at their command. Production in basic steel is on the down grade. Competition for new business becomes more intense, and the latest quotations, despite the benefit afforded by recent cuts in fuel costs, barely pay for the upkeep of greatly extended plants. Orders from the shipbuilding yards for heavy forgings and castings are coming through in slightly better volume, though the general restriction of shipbuilding construction and particularly naval ship work as compared with pre-war requirements, makes progress exceedingly difficult in the face of exceptionally heavy rates and taxes. Provincial and Colonial tramways are taking a slightly increased tonnage of manganese trackwork. Outputs of colliery equipment, castings and fittings for the building trade, railway furnishings, quarry and timber-working tools tend to grow. File works are moderately employed. Instances are to be found of saw manufacturers whose output is mortgaged for three to four months ahead.

South Yorkshire Coal Trade.—Easier conditions characterise every section of the local market. An all round shrinkage in the demand is reflected in rising stocks at collieries. Exports of best steams are much below the average tonnage of three months ago, while deliveries on inland account are only moderate. There is a certain amount of forced selling without, however, any further reduction in official rates. Cobbles and nuts are difficult to market, but slacks are deriving benefit from restricted production. House coal quotations are maintained in face of an excess output. Quotations:—Best branch handpicked, 34*s.* to 35*s.*; Barnsley best Silkstone, 28*s.* to 29*s.*; Derbyshire best brights, 28*s.* to 30*s.*; Derbyshire best house, 25*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* to 25*s.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 23*s.* 6*d.*; Rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; Nutty slacks, 12*s.* to 14*s.*; Smalls, 8*s.* to 10*s.*

PERSONAL.—Messrs. the Hoffman Manufacturing Co., Limited, Chelmsford, state that their Glasgow office has been removed from 62, Robertson-street to 192, West George-street, Glasgow, C. 2. Their telephone number is "Douglas 3869"; telegraphic address, remains "Hoffmann, Glasgow."

OSBORN'S WEATHERPROOF IRON.—Messrs. Samuel Osborn and Company, Limited, Sheffield, inform us that they are now supplying another form of rustless material which they call "Osborn's Weatherproof Iron." Hitherto, the art of polishing has been against the use of rustless material. Such articles as bolts and nuts, and other fittings, where appearance is a secondary consideration, but where resistance to the weather is necessary, can be made in their weatherproof iron, the material being weather resisting in the condition in which they supply it. Their weatherproof iron is being used in large quantities for steam valve spindles; it resists superheated steam better than any material they have previously made. It is also particularly suitable for the manufacture of castings. It is not quite so tough as their rustless plastic steel, but gives very good tensile results.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig iron continues on a very limited scale, and values are still on the downward curve. With output in excess of needs, stocks are steadily accumulating, and there is keen competition for the few orders that come on the market. Merchants who have not fully disposed of their holdings, acquired on the rising market of three months ago, are cutting their losses and underselling makers. A few cheap parcels have been sold to Scotland, but there is now rather less pressure to dispose of holdings. No. 3 g.m.b. is obtainable at 88*s.*, and that may be given as the general market quotation, though there are makers who endeavour to fix the price a little higher. Foundry 4 is 87*s.* and No. 4 forge 86*s.*

Hematite.—East Coast hematite is slow of sale, and easy in price. Nos. 1, 2 and 3 are offered rather freely, but one or two producers quote above the normal figure.

Foreign Ore.—Absolute stagnation is reported so far as foreign ore is concerned. Sellers still base market rates on best rubio at 23*s.* c.i.f. Tees.

Blast Furnace Coke.—Durham blast furnace coke is fairly plentiful and demand is quiet. Good medium qualities are in the neighbourhood of 27*s.* delivered to consumers here.

Manufactured Iron and Steel.—Unsatisfactory and discouraging accounts are given of most branches of the manufactured iron and steel industries. The outstanding exception is the galvanised sheets department. Producers of these articles are fully booked for some months ahead and they report demand unabated. The export price of galvanised corrugated sheets (24 gauge, in bundles) is quite 18*l.* 5*s.* For other descriptions of manufactured iron and steel, export figures are matters of negotiation, but producers adhere to the following agreed rates to home customers: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy steel rails, 9*l.*; and fish plates, 13*l.*

Shipments of Iron and Steel.—Shipments of iron and steel from the Tees Ports last month totalled 85,777 tons, 37,795 tons being pig iron, 2,153 tons manufactured iron, and 45,829 tons steel. Of the pig iron cleared, 25,452 tons went abroad and 12,343 tons went coastwise; of the manufactured iron loaded, 1,049 tons went abroad and 1,104 tons went coastwise; and of the steel cleared, 37,073 tons went abroad and 8,756 tons went coastwise. Scotland was the largest customer for pig iron, taking 6,951 tons; whilst Belgium received 6,353 tons; Italy, 5,180 tons; France, 4,419 tons; Germany, 4,215 tons; and Wales 3,250 tons. India was once more the heaviest buyer of steel, importing 12,371 tons. Other principal receivers of steel were: Argentine, 5,000 tons; Japan, 2,838 tons; Natal, 2,326 tons; Victoria, 1,641 tons; and British East Africa, 1,409 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, WEDNESDAY.

The Coal Trade.—Rather more business has been transacted in the Welsh steam coal trade of late. With tonnage arriving more freely and freights on a cheaper basis in most trades, foreign buyers have come forward for supplies rather more freely. Coal prices, except as regards the very best qualities, which are scarce, have also shown an easy tendency, which has encouraged more buying. Moreover, foreign consumers are no longer able to fall back on stocks accumulated when a national coal strike threatened. The possibility of German reparation supplies being cut off, or much curtailed, is also a factor which buyers of coal abroad cannot afford to ignore. Colliery owners generally expect a further recovery in exports, and, while several more small pits are being closed down as unremunerative, certain collieries recently stopped have been re-started. Shipments of coal as cargo last week totalled 528,598 tons, as compared with 418,468 tons in the previous week. Of the total, 179,599 tons were despatched to France, compared with 181,398 tons; 80,035 tons to Italy, against 33,452 tons; 59,423 tons to South America, against 63,408 tons; 67,575 tons to Spain, against 28,436 tons; 14,040 tons to Portugal, against 15,035 tons; 21,599 tons to Greece, against 4,514 tons; 45,537 tons to British coaling depots, against 37,821 tons; and 60,790 tons to unclassified countries, against 54,004 tons. Exports from Cardiff totalled 282,244 tons, against 235,915 tons; Newport 125,701 tons, against 86,587 tons; Swansea 43,047 tons, against 63,769 tons; Port Talbot 74,583 tons, against 24,591 tons; and Llanelly 3,023 tons, against 7,606 tons. Prices generally show irregularity. Owing to the comparative shortage of best Admiralty qualities, these are firm between 28*s.* and 29*s.* per ton f.o.b., but other qualities are relatively plentiful, and seconds range between 26*s.* 6*d.* and 28*s.* Monmouthshires are between 23*s.* 6*d.* and 26*s.* 6*d.*, while smalls are usually weaker between 14*s.* and 18*s.* per ton f.o.b., according to quality.

Iron and Steel.—Exports of iron and steel products from South Wales, last week, totalled 19,809 tons, compared with 20,321 tons in the previous week. Shipments of tinplates were 8,100 tons against 10,222 tons; blackplates 3,314 tons, against 6,933 tons; galvanised sheets 4,873 tons, against 1,937 tons; and other products 3,522 tons, against 1,230 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There have been no signs of any improvement in the Scottish steel trade this week, and little is now expected before the holidays. The latter commence this week in the Greenock and Port-Glasgow districts, and, shortly after work is resumed there, six works in the Glasgow district, including Motherwell, &c., close down. The demand for steel during the month of July is generally poor, but this year it is likely to be much less than usual. The past week has not brought out many specifications and only actual requirements are being asked for by consumers, although one of the home railway companies has been inquiring for a fair quantity of steel rails and fish plates this week. Other inquiries do not amount to very much. Black sheet makers are fairly well employed on the lighter gauges, but the heavier sorts are not in much request. Galvanised sheets are the subject of good business at the moment. Prices are unchanged and are quoted as under:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{1}{16}$ to $\frac{1}{4}$ in., 12*l.* 10*s.* per ton, all deadweight Glasgow stations.

Malleable Iron Trade.—A quiet tone still prevails in the West of Scotland malleable-iron trade and plant can only be kept running on the day-to-day demand. Little forward business is being booked and the outlook for the future, is far from reassuring. Prices keep steady with "Crown" bars quoted at 12*l.* 10*s.* per ton deadweight Glasgow stations. A little improvement falls to be noted in the re-rolled steel branch.

Scottish Pig-Iron Trade.—There is practically no change to report in connection with the Scottish pig-iron trade this week. The demand is poor as both home and export buyers are placing few orders, and these are mostly of a limited nature. Unless business increases to a considerable extent before long it is anticipated that when the furnaces are put off for the holidays they will not be re-lighted until there is an accumulation of orders. Prices are again a turn easier and mark a slight reduction over the week. They are as follow:—Hematite, 5*l.* per ton deadweight at the steel works; foundry iron No. 1, 5*l.* 1*s.* 3*d.* per ton, and No. 3, 4*l.* 16*s.* 3*d.* per ton, both on trucks at makers' yards.

Scottish Shipbuilding.—The shipbuilding industry in Scotland has been doing rather better recently, and there has been considerably more activity in the yards. This is clearly shown by the returns of vessels launched during the past month or two, but owing to the higher costs of production now prevailing the price required for new tonnage has had of necessity to be raised, with the result that fresh contracts are rather scarcer. About a dozen new orders were officially reported for the past month, but it is highly probable that one or two others were also secured although not yet intimated. The following are the figures of vessels launched during the month of June, and the totals for the year to date:—

	June.		Six Months.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	21	70,071	118	254,367
The Forth	2	4,615	10	18,308
The Tay	—	—	2	3,000
The Dee and Moray Firth	3	2,785	11	10,785
Totals	26	77,471	141	286,460

The figures for the Clyde for the month, which are well over the average for the month of June, were considerably helped by the 20,000 tons of the screw motor liner Aorangi, and only on three other occasions during the past decade has the June output been over the 70,000 ton mark. The total for the year to date is very satisfactory, and shows that quite a fair amount of activity has been going on at the Clyde yards. It compares favourably with other years, excepting, of course, the record year of 1913, when the total for the corresponding period was 348,476 tons, representing 127 vessels launched.

CONTRACTS.—Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, have secured an order for 37 heavy main line locomotives for the Bengal-Nagpur Railway. These locomotives are intended for goods traffic; they are of the 2-8-0 superheater type, with six-wheeled tenders for a gauge of 5 ft. 6 in., and will weigh, in working order, about 113 tons. The contract has been secured in the face of very keen foreign competition. The engines will be built at the firm's Scotswood works, Newcastle-on-Tyne, and it is anticipated that some of them will be shipped in running order in accordance with the firm's usual practice.

THE LATE MR. JOHN HUGHES.—A mining engineer who was associated with some of the important colliery developments in the South Staffordshire coalfield, Mr. John Hughes, died in his 89th year on Saturday last. He was the last survivor of the pioneers who founded, in 1867, the South Staffordshire and East Worcestershire Mining Engineers' Association, and was a member of the Institution of Mining Engineers for nearly 60 years. Mr. Hughes was chief mining engineer to the Earl of Dudley, in which capacity his deductions from an unusual type of fault in one of the Dudley pits indicated to him the existence of a thick coal seam outside the limits of the then existing coalfield. This discovery in 1894 led to the important colliery developments at Baggeridge. For over half a century Mr. Hughes took a large part in public affairs and was for three years Mayor of Dudley.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Saturday, July 5, at 11.30 a.m., at Storey's-gate, S.W.1. Extra General Meeting. Joint meeting with the Institution of Civil Engineers. "Draft Standard Test Code for Hydraulic Power Plants." Drawn up by a joint committee of the Institutions of Civil and Mechanical Engineers.

THE WHITWORTH SOCIETY.—Tuesday, July 8. Summer meeting. At 6.30 for 7 p.m. Dinner at the Holborn Restaurant, London.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, July 8, at 8.30 p.m., at Great George-street, S.W.1. The 30th James Forrest Lecture, entitled "Electrical Progress and its Unsolved Problems," by Professor Elihu Thomson, M.Inst.C.E. Wednesday, July 9, from 8 to 11.30 p.m. Conversazione. Thursday, July 10, at 4.30 p.m. Presentation of the Kelvin Medal, 1923, to Professor Elihu Thomson.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, July 9, at 6 p.m., at the Institution of Electrical Engineers, Victoria-embankment, W.C.2. Informal meeting. Mr. P. R. Coursey will give a talk on the "Manufacture of Condensers."

THE INSTITUTION OF SANITARY ENGINEERS.—Monday, July 7, to Thursday, July 10. International Conference on Sanitary Engineering at the Royal United Service Institution, Whitehall, S.W.1. Monday, July 7, at 10 a.m. Opening of conference by the Minister of Health. Three papers dealing with Public Health Administration. At 2 p.m., three papers on Prevention of Malaria, &c.; at 4 p.m., "Electrically-driven Centrifugal Pumps for Water Supply and Sewage Disposal," by John Bergstrom. Tuesday, July 8, at 10 a.m., ten papers dealing with Activated Sludge. Wednesday, July 9, at 10 a.m. Five papers on Sewerage. At 2 p.m. Seven papers on Disposal of Sewage and Trade Wastes. Thursday, July 10, at 10 a.m. Five papers dealing with Plumbing and House Drainage. At 2 p.m. Three papers on Refuse Disposal. At 3.30 p.m. Four papers on Water Supply.

THE ROYAL AERONAUTICAL SOCIETY.—At a meeting of the Council of the society held on June 17 last, Lieut.-Col. H. T. Tizard was elected Chairman for the ensuing session and will assume office on October 1.

THE ROYAL SANITARY INSTITUTE.—The thirty-fifth congress of this Institute is to be held in Liverpool from the 14th to the 19th inst., under the presidency of the Marquess of Salisbury. The subjects covered by the papers to be read and discussed cover hygiene, sanitation, housing, ship sanitation, &c. A health exhibition is to be held in connection with the Congress.

THE GENERAL ELECTRIC COMPANY, LIMITED.—The annual report of the General Electric Company, Limited, for the year ending March 31, 1924, indicates satisfactory progress. The company made a trading profit of 835,581*l.*, which, after paying interest upon debentures and preference shares, permits 5 per cent. to be paid to the ordinary shareholders and 212,000*l.*, subject to corporation profits tax, to be carried forward. The capital of the company is 6,000,000*l.* and its employees now exceed 17,000, better business conditions having permitted an increase of over 2,000 during the past year.

THE ROYAL AIR FORCE AERIAL PAGEANT.—Aerial races, exhibitions of trick flying and formation flying, and demonstrations of the methods employed in aerial warfare constituted the principal events of the Royal Air Force Aerial Pageant, held at Hendon Aerodrome on Saturday, June 28. A number of new and experimental types of service machines were shown on the ground and in the air, but perhaps the most attractive item, from the point of view of the general public, was the very passable representation of the destruction, by means of torpedoes dropped from Dart torpedo-carrying machines, of an armed enemy merchant cruiser while in the act of holding up a cargo steamer. The Pageant is held each year in connection with the Royal Air Force annual training and the proceeds are devoted to the Air Force Memorial Fund.

SCIENCE SCHOLARSHIP EXAMINATIONS FOR 1925.—The Board of Education have now issued the syllabus for the science scholarship examinations to be held in 1925. The syllabus can be obtained from any branch of H.M. Stationery Office, or through any bookseller, price 6*d.* Scholarships will be awarded in five groups of subjects, viz., Engineering, Physics, Chemistry, Biology and Geology, and will be tenable at the Imperial College of Science, South Kensington. In this new syllabus the Board retain the provision by which inhabitants of villages and the smaller towns are definitely considered ineligible for these scholarships, since only those who have taken laboratory courses at a technical school will be accepted as candidates. This regulation gave rise to strong criticism when first promulgated and has not yet been the subject of a reasoned defence, either official or unofficial. It is obvious that a candidate who by private study could secure one of these scholarships would have to be of somewhat exceptional ability, but this consideration seems to weigh less with the Board of Education than the interests of teachers. It is evident that neither a Faraday nor an Oliver Heaviside would receive any encouragement from the Board of Education as at present constituted.

AUTOMATIC SUB-STATION GEAR; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 13.)

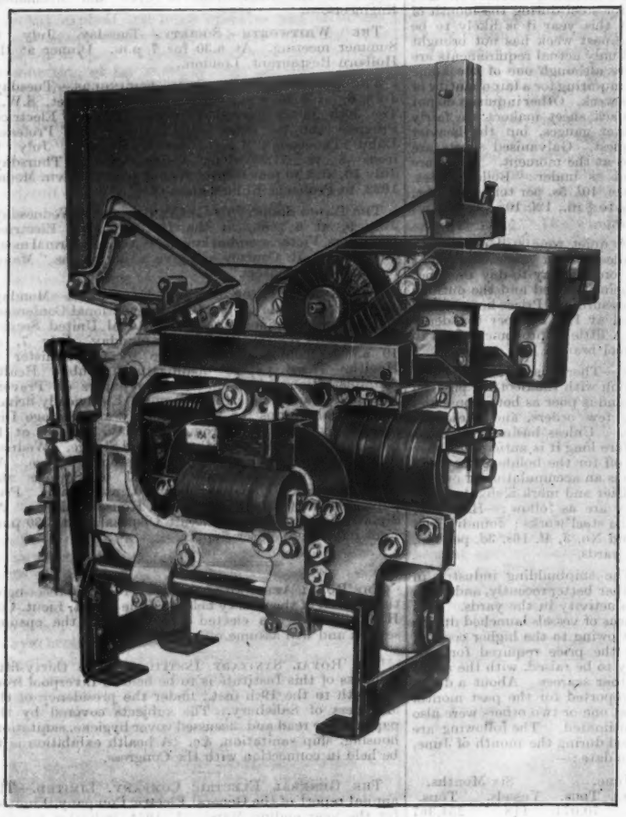


FIG. 3. HIGH-SPEED CIRCUIT-BREAKER IN OPERATING POSITION.

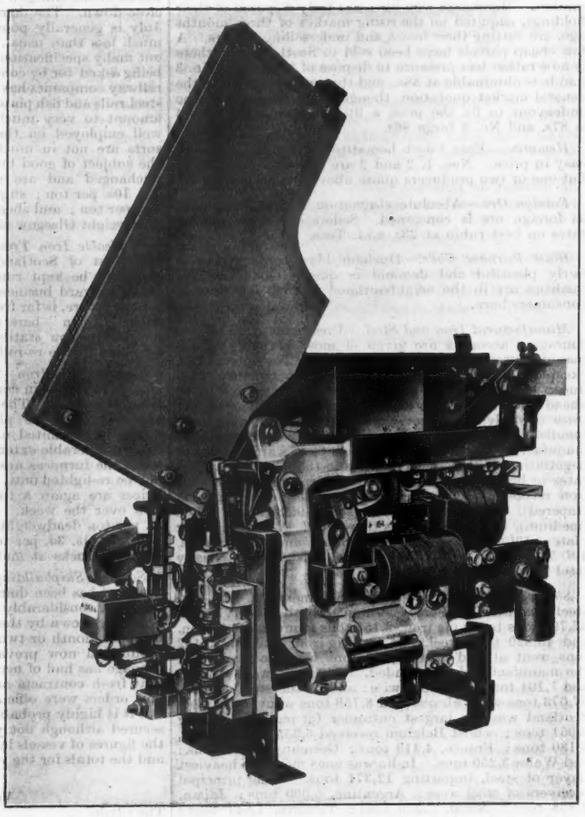


FIG. 4. HIGH-SPEED CIRCUIT-BREAKER WITH ARC SHIELD LIFTED.

THE INTERNATIONAL LIFE-BOAT CONFERENCE.

UNDER the auspices of the Royal National Life-Boat Institution, which celebrates its centenary this year, a Conference was held in the Westminster City Hall from June 30 to July 3, of representatives from the various European life-boat services. Technical and financial aspects of the question of life-saving at sea came up for discussion between the different authorities concerned. The proceedings included an inspection by Admiral of the Fleet Sir Doveton Sturdee, of typical boats from the British, Dutch, Danish, Swedish, French and Norwegian fleets, which were assembled in the Thames, off the Temple steps.

A very favourable impression was created by the William and Kate Johnston, of New Brighton (on the Mersey), the new British Barnett twin-screw motor life-boat. Fitted with two 90-h.p. engines she can maintain a speed of 10 knots. Her equipment includes a searchlight, jumping net, and oil-wave subduer, the latter permitting of an oil layer 2 ft. broad being squirted around the vessel on the water surface. A B.S.A. line-throwing shoulder gun is fitted, having a range of 80 yards. A technical description of this boat appeared in our issue of April 21, 1922. The other British representative, the J. W. Archer, of Teesmouth, is a Watson (cabin) motor boat of 45 ft. length, and is fitted with a single 90-h.p. motor. Of the European units, the Dutch Brandaris attracted much attention, and received the commendation of the Admiral. She is a twin-screw motor boat of 60 ft. length, fitted with a semi-Diesel opposed twin-cylindered de Booy engine of 90 h.p. The vessel is one year old and is one of eleven motor boats possessed by the Dutch. The other vessels on view were the Dutch low-draft steam-boat Prins der Nederlanden, of 55 ft. length, the Danish 36 ft. motor boat Anholt Hayn, the Swedish Justus A. Waller, 62 ft. in length, with an auxiliary motor, the French Calais Station, a 36 ft. twin-motor boat, and the Norwegian Christian Boers, the last a sturdy 50 ft. sailing vessel used for long range cruising in the fisheries.

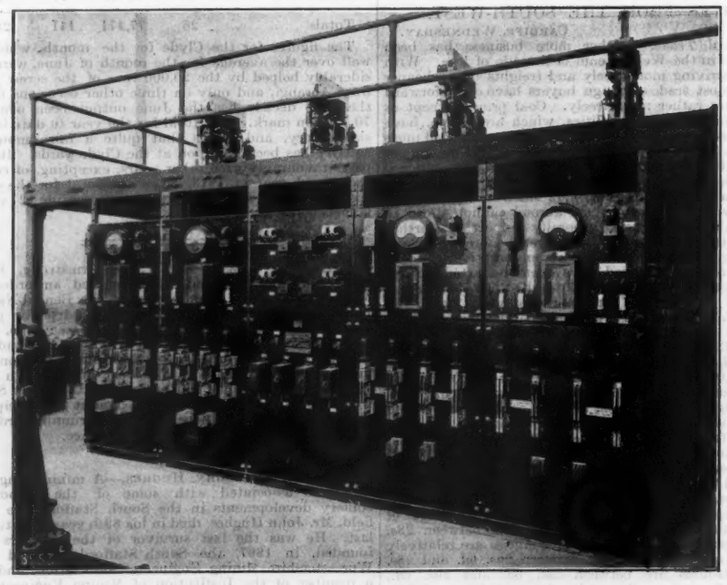


FIG. 5. BOARD CONTAINING FOUR 2,000-AMP. AUTOMATIC FEEDER PANELS.

DIRECTORY OF PAPER MAKERS, 1924.—This directory for the current year, the 48th annual edition, published at the price of 5*s.* net, 5*s.* 6*d.* post free in the United Kingdom, by Messrs. Marchant Singer and Co., 47, St. Mary Axe, E.C. 3, contains an alphabetical list of paper makers in England, Wales, Scotland and Ireland, giving the classes of paper manufactured, the plant of the works, the output, &c.; similar information is given concerning paper enamellers, surfacers, &c.; other sections cover paper mills, lists of makes, trade designations, &c. The paper trade customs, the sizes of papers, &c., form the subjects of separate chapters.

PUMPS AND PUMPING MACHINERY; BRITISH EMPIRE EXHIBITION.

(*For Description, see Page 2.*)

FIG. 28.

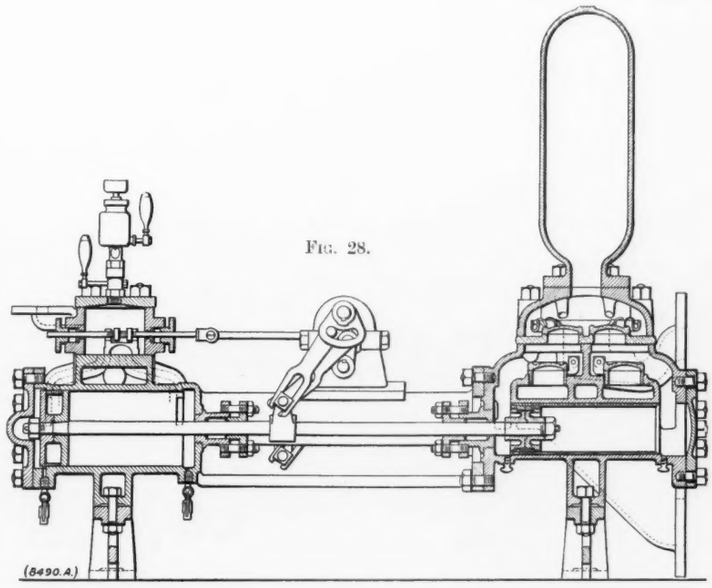
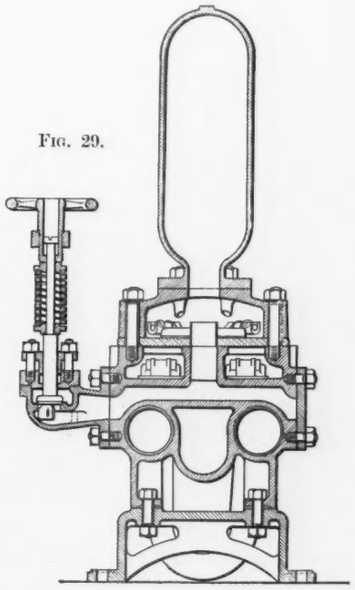


FIG. 29.



FIGS. 28 AND 29. DUPLEX PUMP WITH TWELLS VALVE GEAR; MESSRS. HAYWARD-TYLER AND CO., LIMITED.

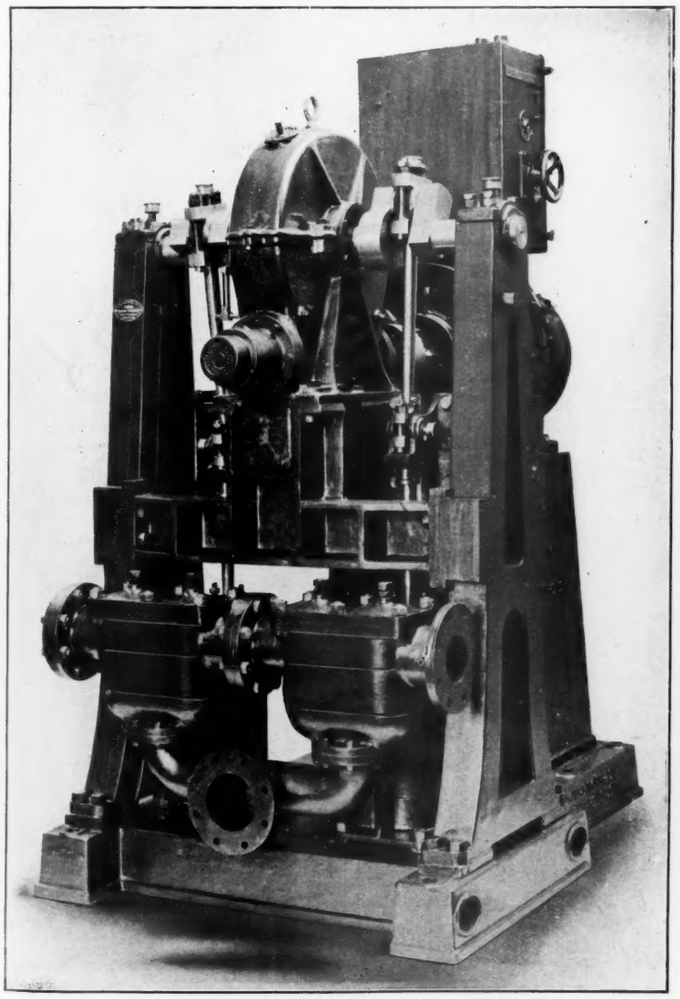


FIG. 30. VERTICAL PISTON COOLING PUMP; MESSRS. HAYWARD-TYLER AND CO., LIMITED.

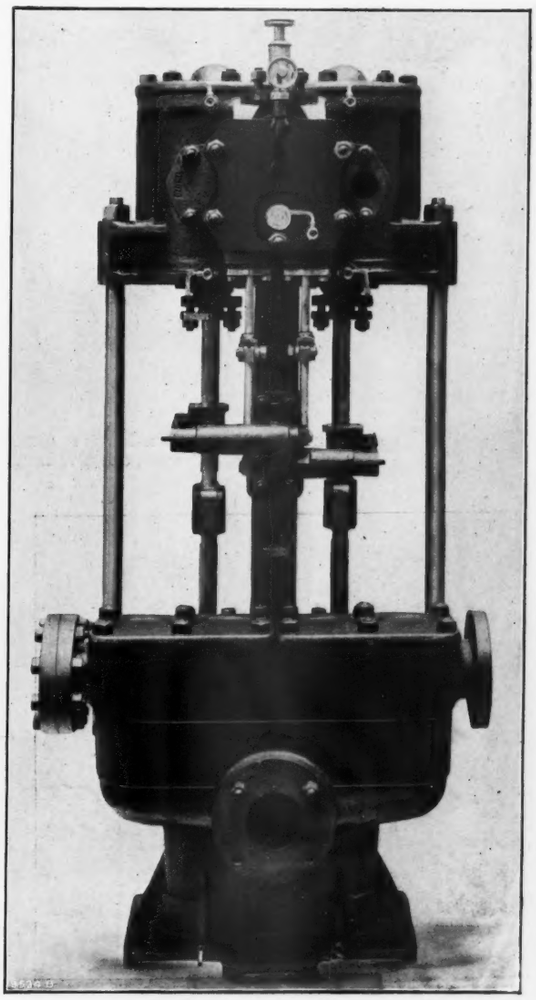


FIG. 31. DUPLEX STEAM PUMP; MESSRS. HAYWARD-TYLER AND CO., LIMITED.

(*To face page* 4.)

PUMPS AND PUMPING MACHINERY; BRITISH EMPIRE EXHIBITION.

(*For Description, see Page 2.*)

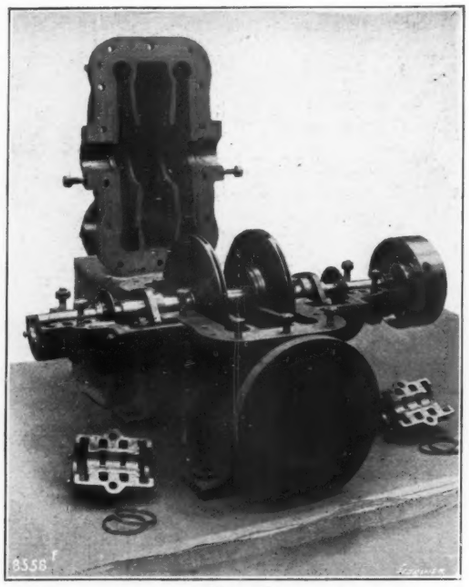
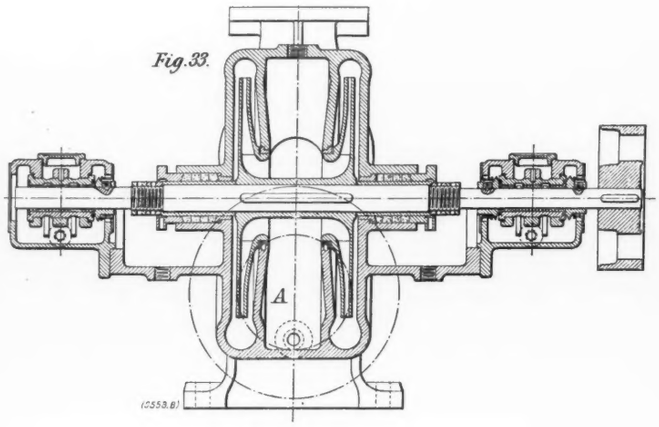
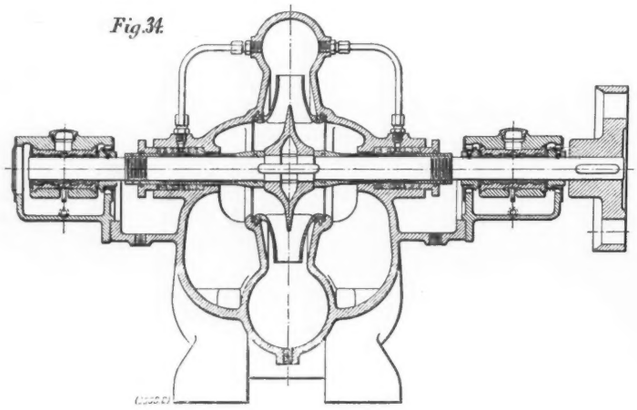


FIG. 32.



FIGS. 32 AND 33. 3-IN. OPPOSED-IMPELLER EXTRACTION PUMP; THE MIRRLEES WATSON COMPANY, LIMITED.



FIGS. 34 AND 35. 10-INCH LOW-LIFT CONDENSATE PUMP; THE MIRRLEES WATSON COMPANY, LIMITED.

FIG. 35.

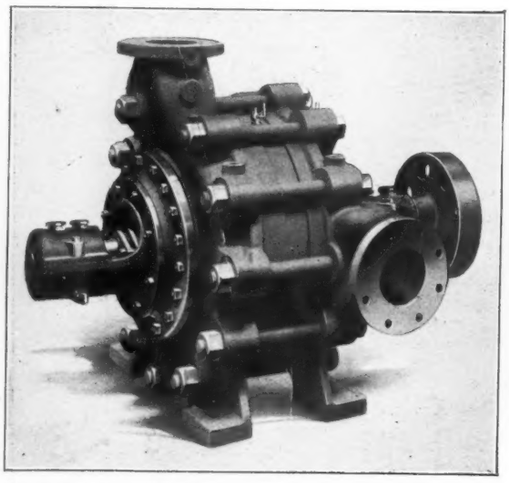
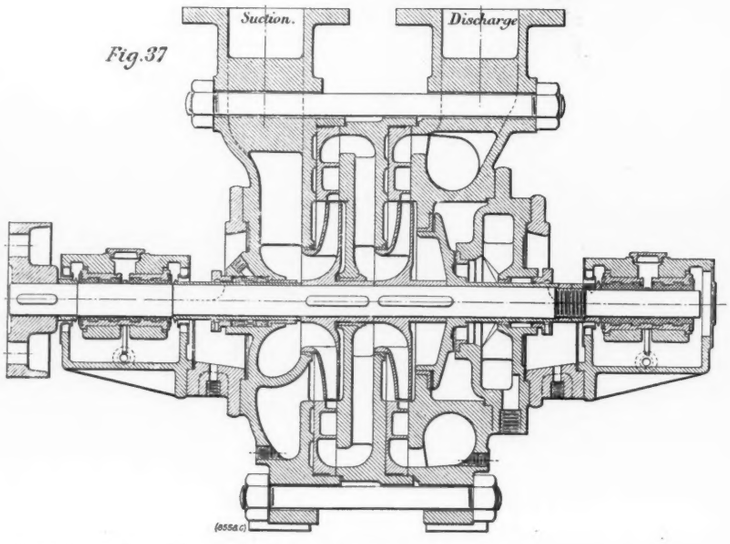


FIG. 36.



FIGS. 36 AND 37. MULTI-STAGE HIGH-LIFT PUMP; THE MIRRLEES WATSON COMPANY, LIMITED.

(*To face page 5.*)

(To face page 8.)

SENTINEL-CAMMELL STEAM RAIL MOTOR AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 6.)

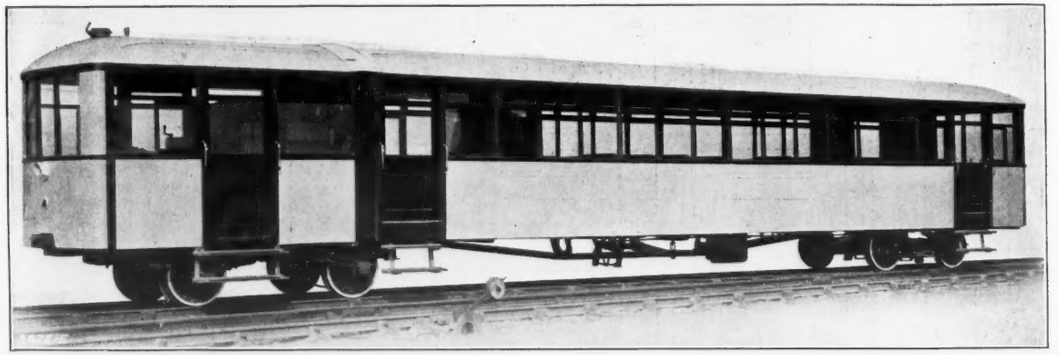


FIG. 68. GENERAL VIEW OF COACH.

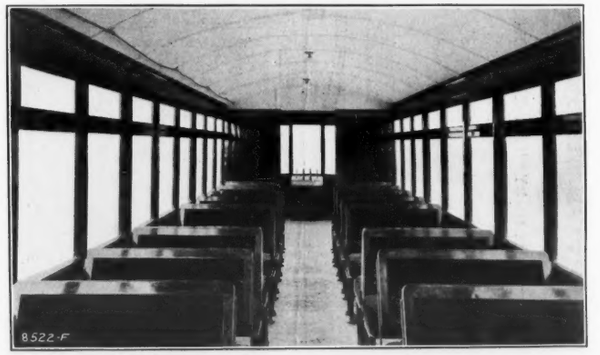


FIG. 69. MAIN PASSENGER COMPARTMENT.

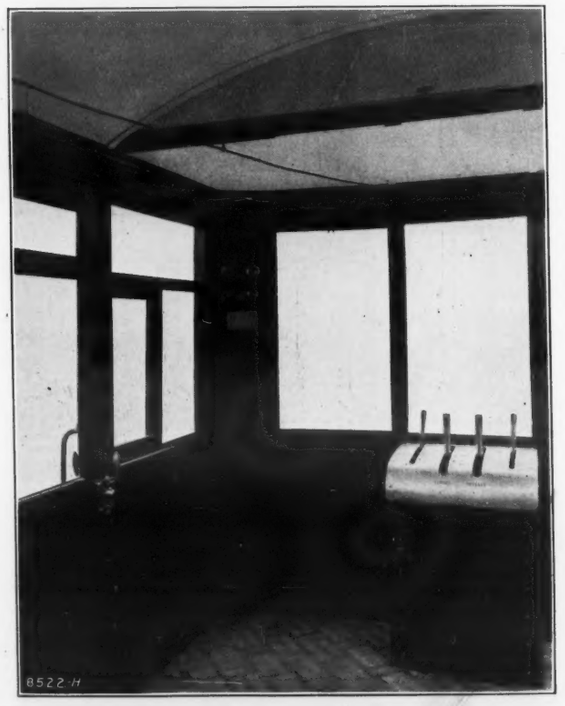


FIG. 70. DRIVER'S AND LUGGAGE COMPARTMENT.

FIG. 71. THE ENGINE END.

FIG. 72. SMALL PASSENGER COMPARTMENT.

CONTROL TRAILER CAR FOR THE METROPOLITAN RAI

CONSTRUCTED BY THE METROPOLITAN CARRIAGE, W[illegible] AND FI[illegible]

(For Des[illegible] see Page

FIG. 73.

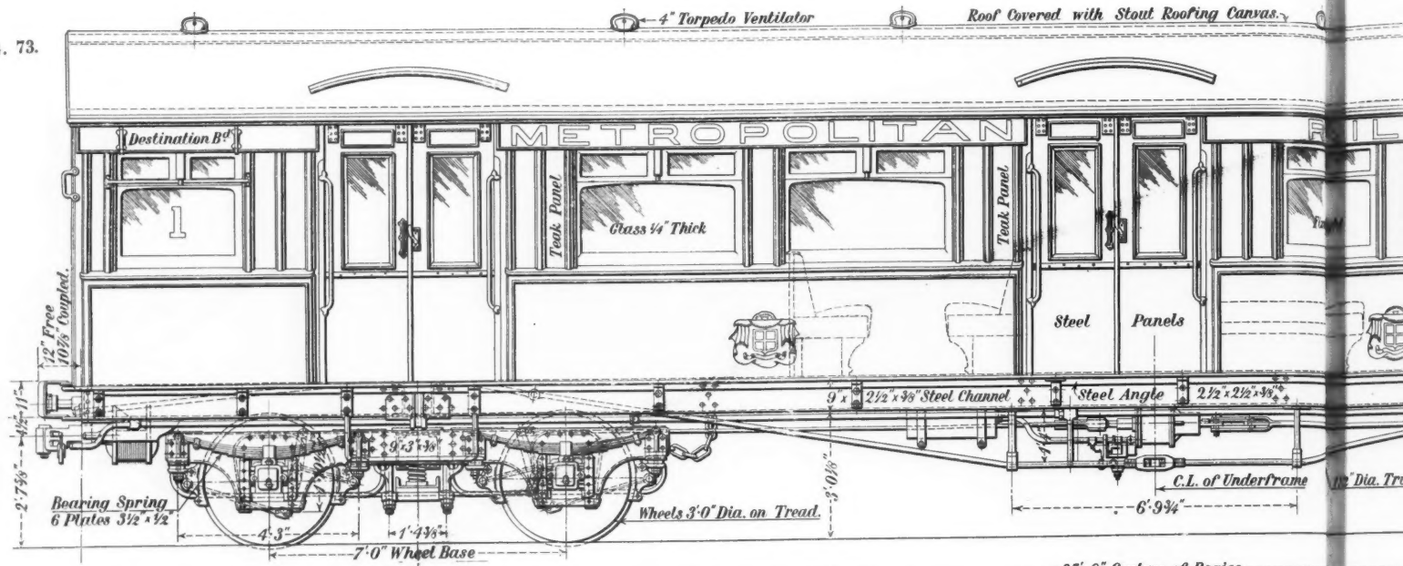


FIG. 74.

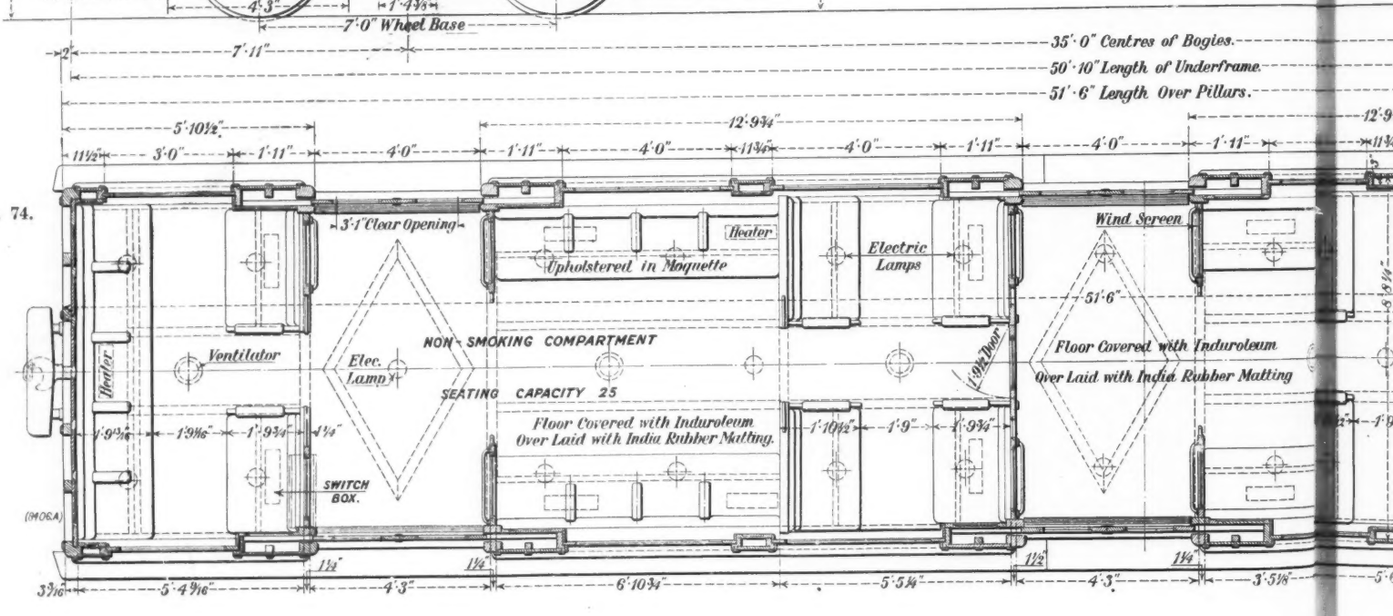


FIG. 77.

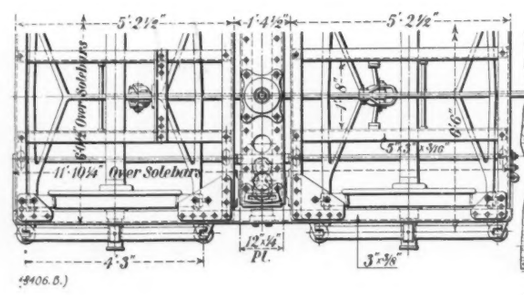
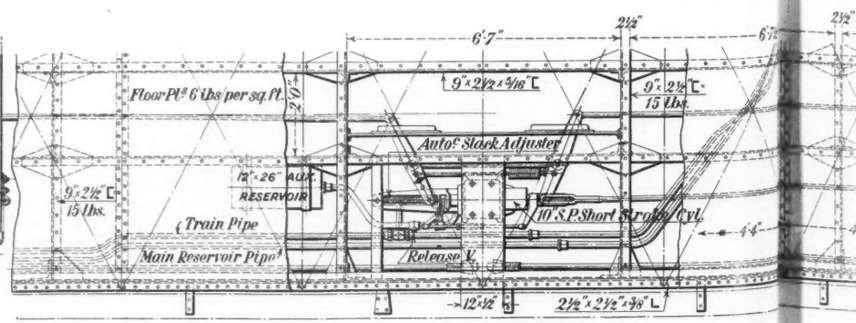


FIG. 78.

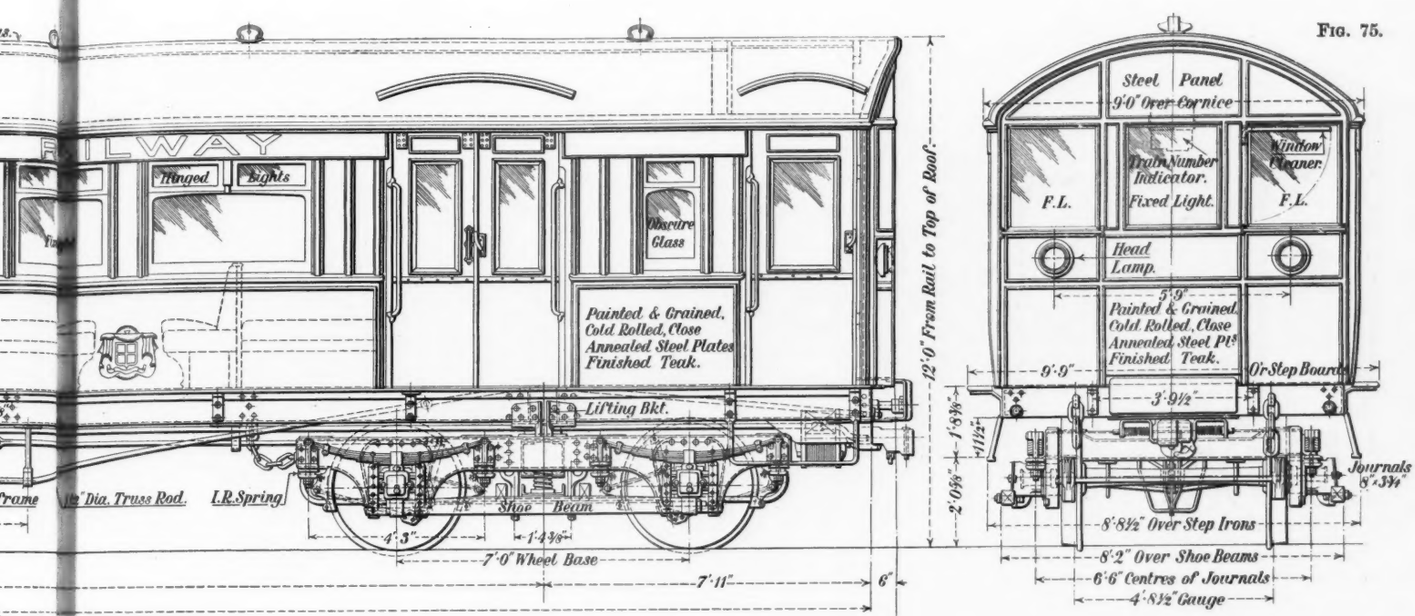

6'7"
2¼"
Floor Plate 6 lbs. per sq. ft.
9" x 2½" x 5/16" L
9" x 2½" L 15 lbs.
Auto. Slack Adjuster
12" x 26" AUX. RESERVOIR
9" x 2½" L 15 lbs.
Train Pipe
10" S.P. Short Stroke Cyl.
Main Reservoir Pipe
Release V.
12" x 12"
2½" x 2½" x ⅜" L

LIT[E] RAILWAY AT THE BRITISH EMPIRE EXHIBITION.

AGE, W[AGON] AND FINANCE CO., LIMITED, ENGINEERS, BIRMINGHAM.

(For Dem[ons]., see Page 6.)

FIG. 75.



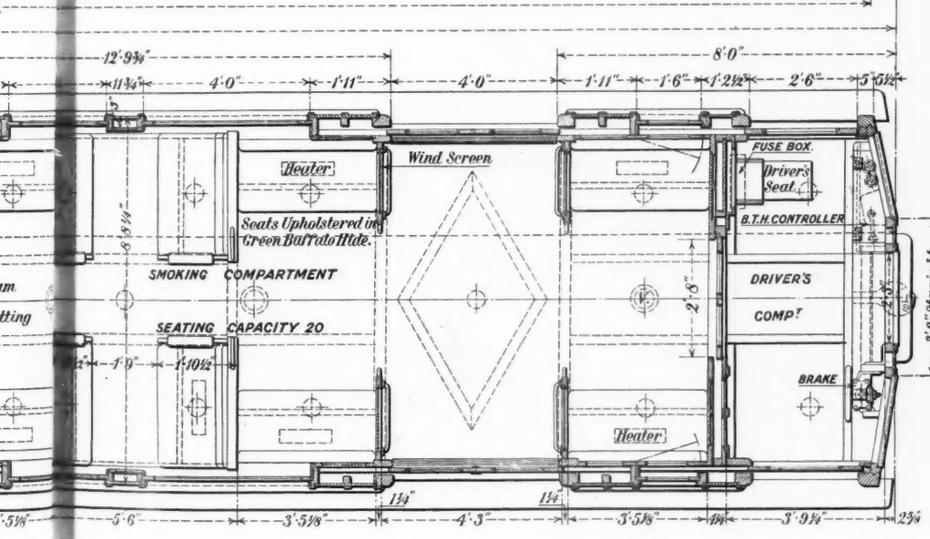
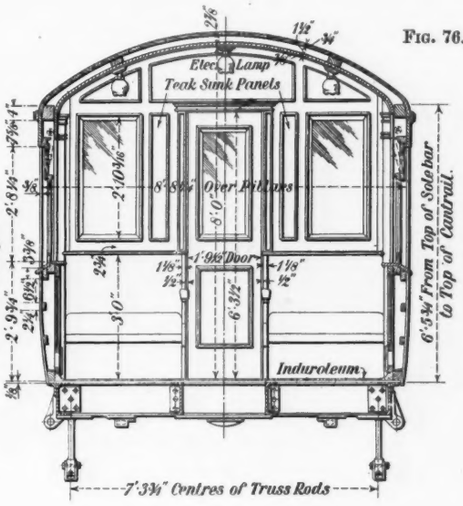
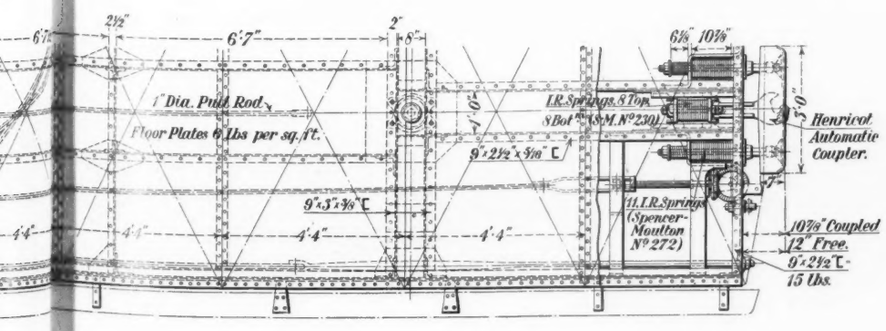


FIG. 76.





LENGTH OVERALL, COUPLED ...	52 FT. 6 IN.
WIDTH OVER FOOT-BOARDS ...	9 FT. 9 IN.
HEIGHT FROM RAIL TO TOP OF ROOF	12 FT.
SEATING ACCOMMODATION, TOTAL PASSENGERS	45

CONTROL TRAILER CAR FOR THE METROPOLITAN RAILWAY AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE METROPOLITAN CARRIAGE, WAGON AND FINANCE CO., LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 6.)

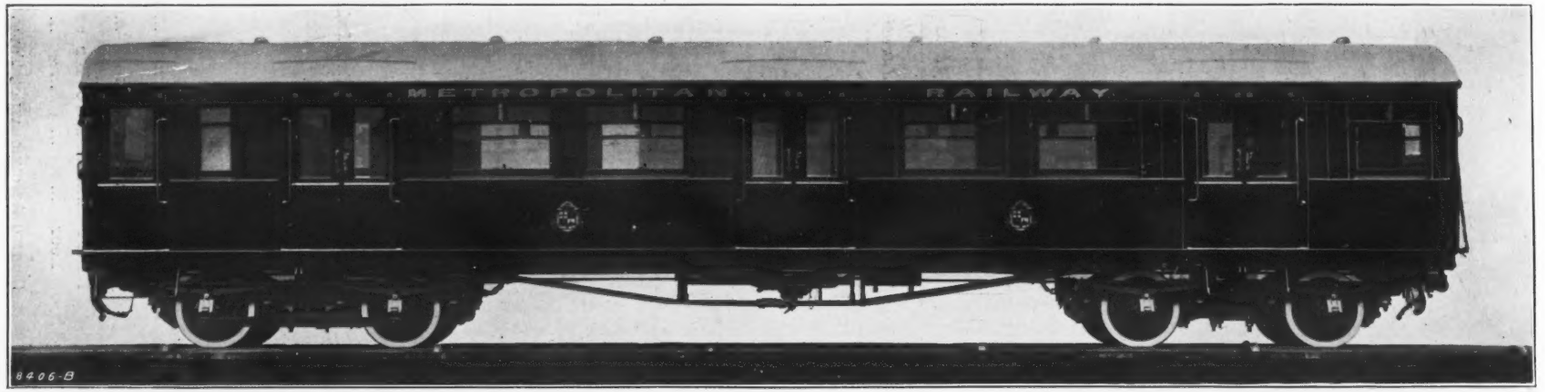


FIG. 79. EXTERIOR OF CAR.

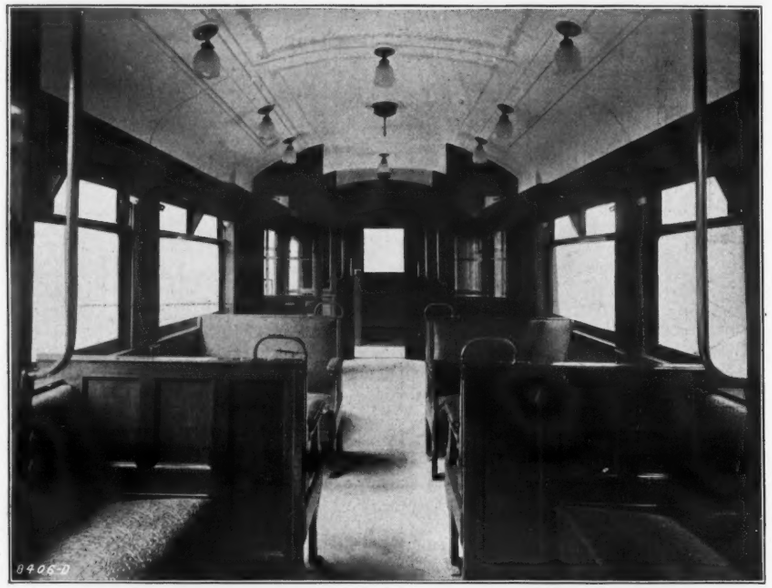


FIG. 80. SMOKING COMPARTMENT.

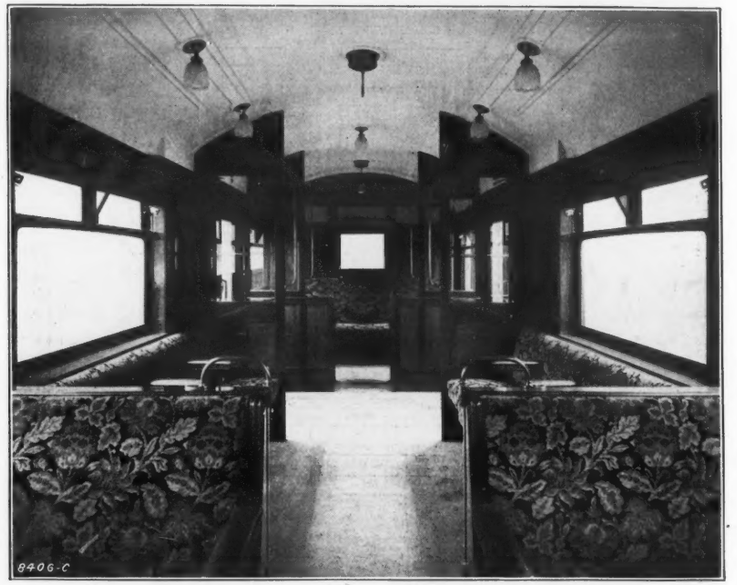


FIG. 81. NON-SMOKING COMPARTMENT.

(*To face page* 9.)

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. PLATT BROTHERS AND CO., LIMITED, ENGINEERS, OLDHAM.

(*For Description, see Page* 11.)

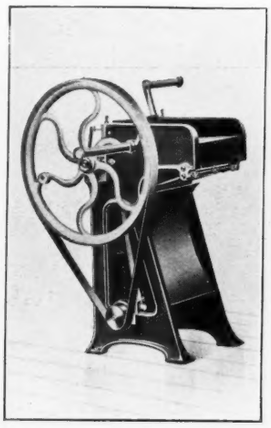


FIG. 1. HAND POWER ROLLER GIN.

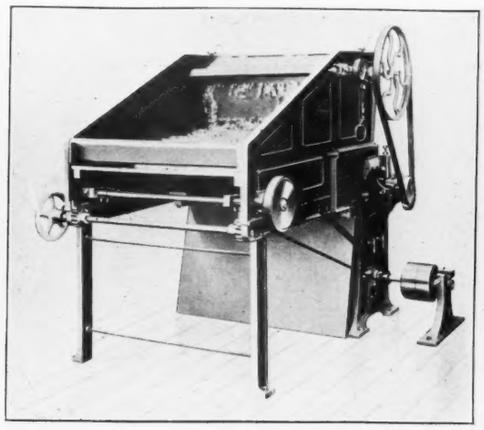


FIG. 2. SINGLE-ACTION MACARTHY GIN.

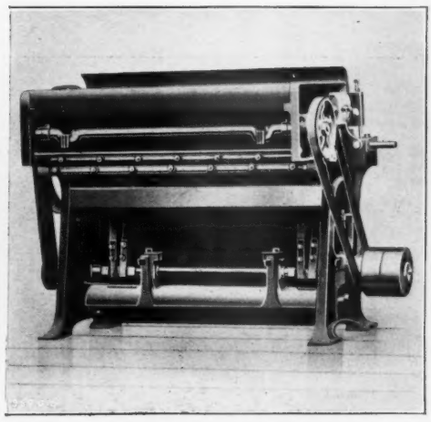


FIG. 3. DOUBLE-ACTION MACARTHY GIN.

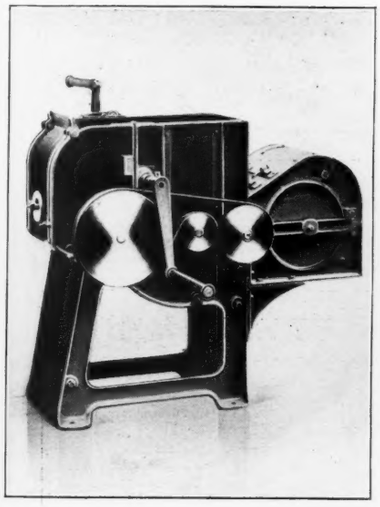


FIG. 4. HAND SAW GIN.

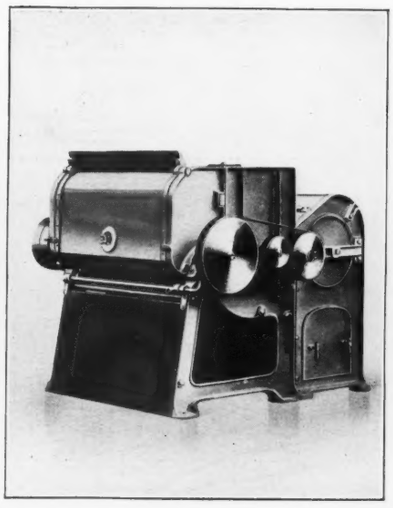


FIG. 5. POWER SAW GIN.

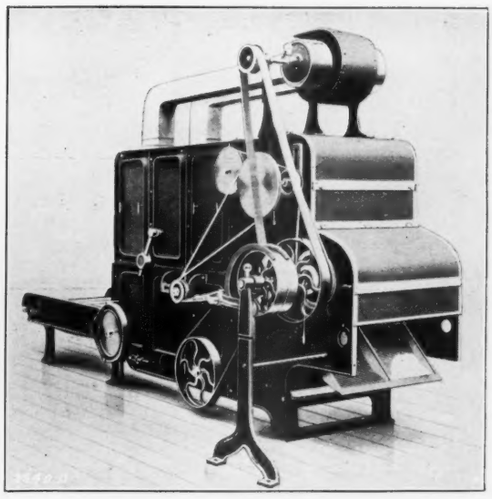


FIG. 6. HOPPER BALE BREAKER.

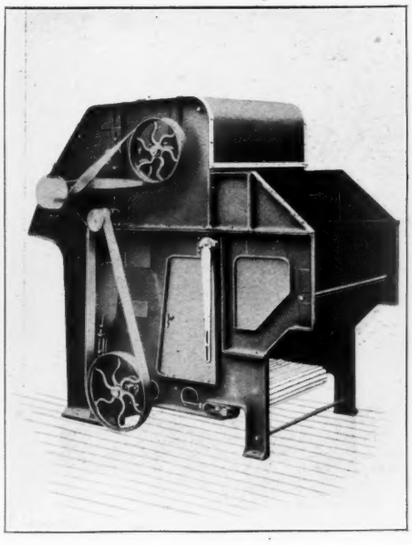


FIG. 7. HOPPER OPENER.

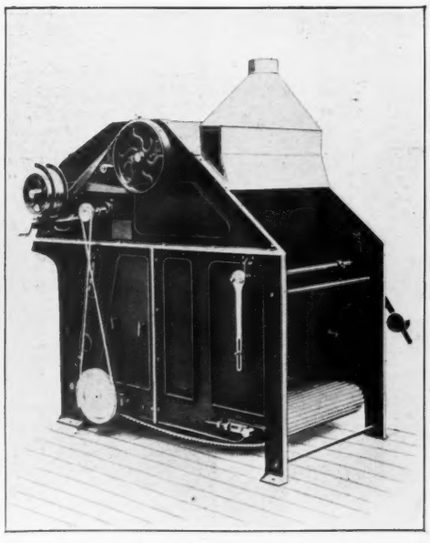


FIG. 8. HOPPER FEEDING MACHINE.

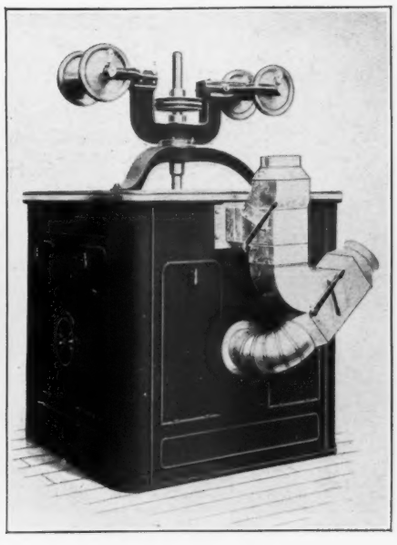


FIG. 9. CRIGHTON OPENER.

(*To face page* 12)

AUTOMATIC SUB-STATION GEAR; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 13.)

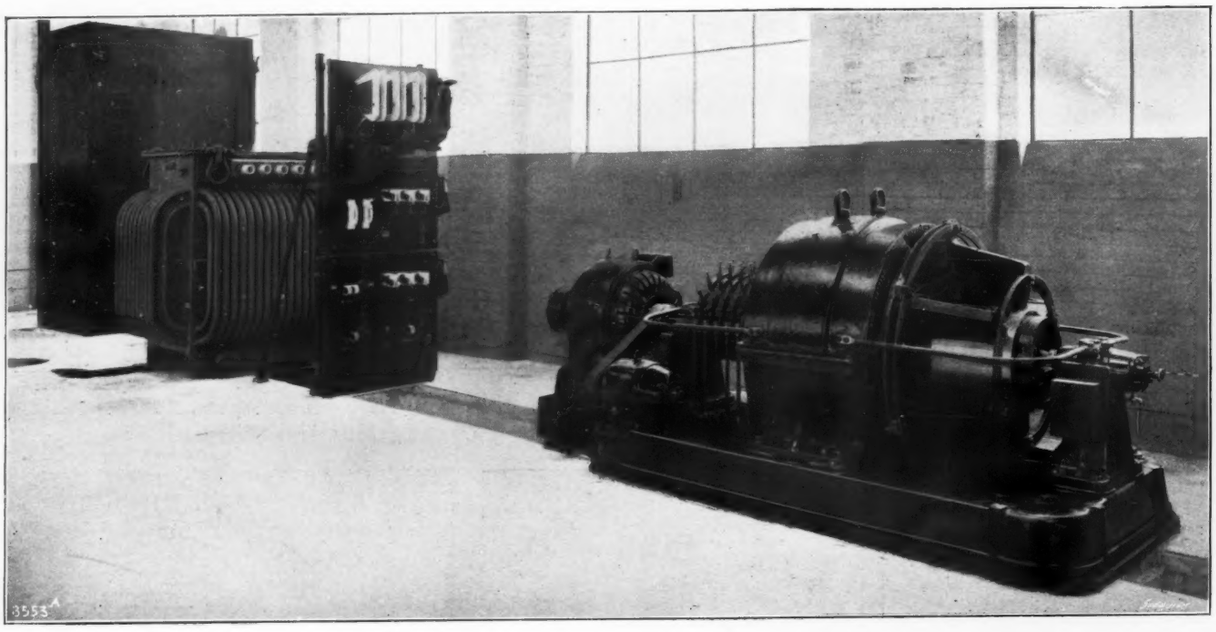


FIG. 1. HIGH AND LOW TENSION GEAR FOR ONE ROTARY CONVERTER.

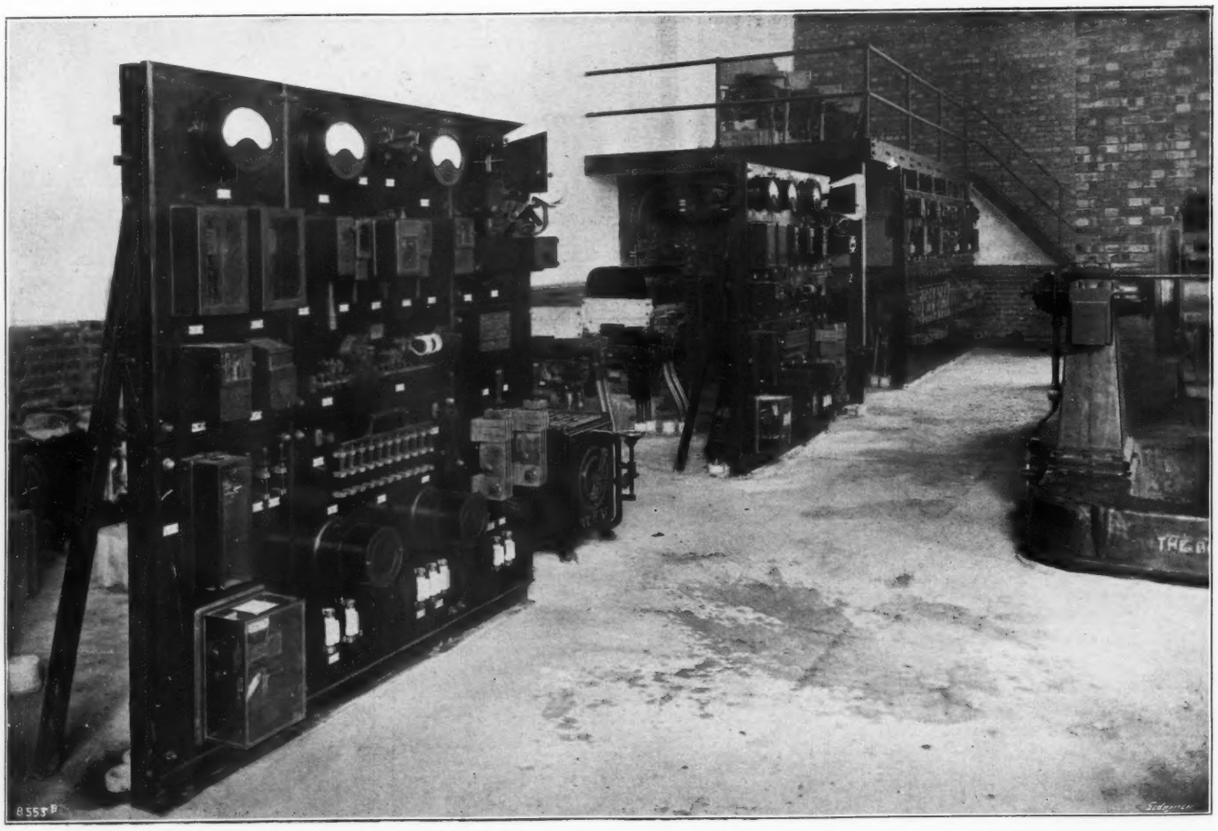


FIG. 2. GEAR CONTROLLING TWO 1,200-KW. ROTARY CONVERTERS ON TRACTION SERVICE.

(*To face page* 13.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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ENGINEERING.

FRIDAY, JULY 4, 1924.

SHORT-WAVE RADIO COMMUNICATION.

IN view of the fact that the earliest experiments on the propagation and reception of electric waves were carried out by Hertz with waves only a metre or so in length, it is perhaps rather remarkable that the subsequent utilisation of these waves as a practical means of communication over long distances has been almost entirely confined to waves of several hundreds, or even thousands, of metres in length. Hertz himself showed that electric waves could be reflected, and it is obvious that a more or less parallel beam of waves produced by reflection would have considerable advantages over waves radiated equally in all directions, particularly in reducing the power required to cover a given distance, reducing interference between different stations, and reducing the possibility of messages being picked up by unauthorised persons. For reflection to be possible, however, short waves are essential, since the aperture of the reflector must be equal to at least three or four wave-lengths. It would thus be impracticable to construct a reflector to deal with the waves varying from 1,000 metres to 25,000 metres in length at present used in long-distance radiotelegraphy.

The beam system, employing short waves and reflectors, was employed by Senator G. Marconi in some of his first experiments in this country over 28 years ago, and the advantages of the system were further referred to by him in a paper before the Institution of Electrical Engineers in March, 1899. Since that time, until comparatively recently, however, but little research work on the application of short waves to radio communication has been carried out. This apparent neglect was largely due to the difficulty of producing short waves of sufficient power, and also to the supposed high attenuation of the waves when transmitted over any considerable distance of land or sea. The difficulties of producing and receiving these waves have now been practically overcome by modern valve apparatus, and that many of the objections raised to their use were more apparent than real has been amply demonstrated by the recent experimental work of Senator Marconi and Mr. C. S. Frankin. Some particulars of this work were given in an interesting and important paper read by the former before the Royal Society of Arts on Wednesday last.

The most important of the experiments described were carried out between Poldhu in Cornwall and the s.y. Elettra in various localities, the wave-length used being of the order of 100 metres. These experiments, in Senator Marconi's opinion, prove that the general impression prevailing amongst experts as to the behaviour of short waves is erroneous in several important respects. For the wave-length mentioned, the observations indicate that the day ranges are reliable and considerable, and that the night ranges are much greater than had been anticipated. It was also demonstrated that intervening land did not present any serious obstacle to the propagation of the waves. Another important fact has transpired with respect to day ranges; it has been established that the strength of signals received during the hours of daylight varies definitely and regularly in inverse proportion to the mean altitude of the sun above the horizon in the region intervening between the transmitting and receiving stations.

In one series of tests referred to in the paper, the transmitting apparatus at Poldhu consisted of eight standard M.T.2 valves worked in parallel, the input to the valves amounting to 12 kw. The radiation obtained was about 9 kw. at 97 metres wave length. With a parabolic reflector directed towards Cape Verde, the measured signal strength in that direction proved to be equal to that which would have been received from an aerial radiating 120 kw. without a reflector. After preliminary tests carried out on the Elettra in Falmouth Harbour, the vessel proceeded to Cape Finisterre, and a series of tests was carried out with the reflector at Poldhu dismantled. After rounding Cape Finisterre, it was anticipated that the intervening land would have cut off signals during the day-time and greatly weakened them at night, but this was found not to be the case. Signals however, were weakened during the day according to the distance and to the altitude of the sun, but were clearly received off Seville, which is 780 miles from Poldhu, after having traversed practically the whole of Spain consisting of over 300 miles of high and mountainous country. Night signals were always particularly powerful. Good signals were afterwards secured in daylight at Gibraltar, Tangiers and Casablanca, the latter situated 970 miles from Poldhu.

For the subsequent tests, the reflector at Poldhu was brought into use, and the yacht proceeded to St. Vincent, Cape Verde Islands, where it was found that reception was still possible in daylight for a few hours after sunrise and for some time before sunset, although the anchorage was partially screened by mountains; the distance covered was about 2,230 nautical miles. Night signals could always be received at St. Vincent even with the receiving aerial disconnected. The strength of these night signals was estimated at 80 to 100 microvolts per metre length of the aerial, and with this signal strength no trouble was experienced from atmospheric disturbances. The power of the Poldhu transmitting station was then gradually reduced from 12 kw. to 1 kw., and even with the latter power, Senator Marconi stated, the signals received at St. Vincent were stronger than would be necessary for commercial communication. The signals with 1 kw. were, in fact, considerably stronger than those received from Carnarvon or from any other high-power European or American station. As a result of these tests, Senator Marconi is satisfied that reliable commercial services for a considerable portion of the 24 hours of a day could be carried on over distances of at least 2,300 nautical miles using only 1 kw. of energy at the transmitting station.

On the conclusion of these experiments, which were carried out in April and May of last year, the

transmitting apparatus at Poldhu was improved and the power increased to about 20 kw. Further experiments have been carried on since February of this year, at first with a short-wave receiver installed on the ss. Cedric and employed on a journey to New York and back. No reflectors of any kind were used for the experiments which were carried out on a wave length of 92 metres with an input-power of 21 kw. giving a radiation of about 17 kw. The results showed that signals could be received in daylight up to a distance of 1,400 nautical miles. Signals of great intensity were received at Long Island during periods of darkness extending over the whole distance between the transmitting and receiving stations, and of less intensity when the sun was above the horizon at either end. The variation of the intensity of the received signals inversely as the mean altitude of the sun above the horizon, was amply confirmed. In connection with these tests it is particularly interesting to note that the signals transmitted from Poldhu were received quite clearly in Sydney, N.S.W., every day from 5 p.m. to 9 p.m. G.M.T., and also between 6.30 a.m. and 8.30 a.m. At Montreal, good reception was found to be possible for 16 hours out of the 24.

In consequence of the rather unexpected reception of those signals in Australia, it was decided to attempt to communicate with that country by wireless telephony. For this purpose, the power was further increased to a total of 28 kw. of which 18 kw. was supplied to the main oscillating valves, 8 kw. to the modulating valves, and 2 kw. to the drive valves, the object of which is to keep the wave length steady. The wave length used was again 92 m., and no reflectors were employed. In spite of the fact that the apparatus used was of a rather experimental character, ordinary speech transmitted from Poldhu was successfully received on May 30 last, the date of the first attempt. This is certainly a very remarkable achievement in view of the low power employed; and is one which marks a most important stage in the development of radio communication.

The various problems connected with the production of short-wave commercial transmitters capable of dealing with powers up to about 50 kw., Senator Marconi stated, had now been solved, so that the construction of the necessary apparatus presented no difficulty. He added that while no reflectors had been employed in the long-distance experiments above referred to, their use would enormously increase the effective strength of the signals. In this connection he mentioned some experiments carried out a few weeks ago between Poldhu and Buenos Aires, a distance of 5,820 nautical miles. With a 21 kw. input and using the same wave length of 92 m. in conjunction with a parabolic reflector directed towards South America, very strong signals were received in Buenos Aires over 10 hours of each day. The radiation in the direction of South America was found to be equal to that from an ordinary aerial radiating about 300 kw.

In conclusion, Senator Marconi expressed the opinion that with comparatively small stations of the type referred to above, a far greater number of words per 24 hours could be transmitted between England and her distant Dominions than would be possible by means of the high-powered stations now contemplated. He further pointed out that the low capital and operating costs of such stations, together with their capacity for working at very high speeds, would render possible substantial reductions in telegraphic rates—a matter obviously of considerable importance to the development of the Empire.

SAFETY PRECAUTIONS FOR POWER PRESSES.

SOONER or later, without recognising what they are doing, many press operators will take a chance on the quickness of their hand anticipating that of the tool, and in a certain number of such trials the tool will win once, leaving the operator, as a rule, with a permanently mutilated hand. The experience is as well known in press shops as is the similar trouble with saws and spindles in joineries, and the general prevalence of risk-taking and carelessness is shown by the number of accidents reported to the Home Office year after year. It seems to be clear that a shopful of press workers cannot be trusted to look after themselves unfailingly, and that the presses must take their part in avoiding accidents that are deplorable to all parties.

This is the considered view of the Home Office, confirming that of the Prevention of Accidents Committee of the Tin Box Trade Board, and a "Safety Pamphlet" that the Home Office has just published,* describes in simple language the several dangers attendant on the use of power presses, and illustrates a considerable number of devices and circumstances of work by which these dangers can be reduced and "serious accidents to press-operators can all be prevented." Over 60 such devices are illustrated and described, and the subject is further elucidated by a discussion under separate heads of the several causes of accidents and the ways in which they may be respectively avoided. For the designs reference must be made to the illustrations in the original, which form a useful compendium of what has been done up to date.

Accidents are grouped as due to the press mechanism, such as inefficient fencing of gears, fly-wheels, &c., failure of clutches, inefficient trip gear, absence of stops to prevent overrunning, imperfect press control, inefficient brakes, worn slides, clogged press mechanism; methods of work-feeding, holding, and removing work; inefficient guards and other safety devices—unsuitable or ill-kept guards, hand work required in the danger zone, press unlocked during setting, repairs, &c., and unsuitable working conditions—temperature, lighting, seating, instruction and discipline. For some years past a special form of report on accidents caused by power presses has been in use in one part of the country, describing in detail the leading mechanical particulars of the press concerned, the cause of accident, and other circumstances. The present report would have been more enlightening as to the relative importance of the several groups of causes if it had given a summary of the experience derived from these returns. As it is, the reader is left to regard every possible cause as important, and while this is not as impressive a caution, it may be safer.

Broadly, the means of safety seem to lie in preventing the operator from getting his hands between the moving parts when they are in motion, or in tripping, stopping, clutching, or otherwise locking the press so long as he has them there. The safety mechanism is said to suffer both from wear and from clogging when it is not properly looked after, and a form of periodical report on the examination of each press is strongly recommended, in which the condition of each detail is described, together with details of any repairs that had to be done. Safety devices, however, ingenious, are said to be insufficient as a precaution without auxiliary guards for tools and dies, and closed tools should be used wherever possible.

The general working conditions, as indicated under that head in the grouping of causes, are held to be of considerable importance, and in particular it is agreed that operators should be forbidden to talk or be talked to while in charge of a press, or be subject to any other distraction from the constant attention that is the condition of safety.

The report discloses the old story of safety devices being frustrated by the intentional act of the operator, who from conservatism or some other reason prefers not to use them. On the other hand it is found that, once they are introduced, operators get to prefer working with them; and proof has been received that on certain presses as much as 25 per cent. increase in output has been obtained because of the greater confidence with which the operators work.

* "Fencing and Other Safety Precautions for Power Presses," H.M. Stationery Office, 1s. 6d. net.

PROCEEDINGS OF THE FIRST WORLD POWER CONFERENCE.

H.R.H. THE PRINCE OF WALES extended a welcome to the delegates from all parts of the globe to the First World Power Conference, when he opened the proceedings in the Conference Hall of the British Empire Exhibition on Monday, June 30. This conference was organised by the British Electrical and Allied Manufacturers' Association in co-operation with many of the leading technical and scientific institutions at home and abroad. The intention of the promoters was to gather together the authorities of every country to discuss questions relating to the further development, conservation and economic use of the available power resources of the world. The problems for discussion were placed before the authorities in the different countries and papers to the number of over 300 were submitted for consideration. These are to be discussed at the meetings, which will continue until July 12.

OPENING PROCEEDINGS.

At the meeting on Monday the Earl of Derby, K.G., presided, and very briefly asked the Prince of Wales to open the conference. In doing so, His Royal Highness said that we had become accustomed to the idea of an international clearing house for many things, and in the League of Nations had seen international co-operation at work on political and labour questions and matters relating to law. The deeper questions connected with industrial progress and equipment, with natural resources, with the conservation of energy and of fuel and with standardisation of design and manufacture, had hitherto been examined by each country in isolation. The effort to create for industry what it was intended the League of Nations would do for politics, was the true purpose of the World Power Conference. It was difficult to conceive of any industry in which power did not play a part. The social structure was in a sense bound up with the effective use of power for industrial purposes, and there were many reasons to support the view that the weakness of the social structure in an industrial state was due to inefficient or inadequate utilisation of power. Finance, science and research were universal, but the effective utilisation of the results derived from the three activities was not universal, and in this disparity was found one of the greatest obstacles to progress. International co-operation might emerge from the realms of ideals to practical realisation as a result of the labours of the World Power Conference.

Acknowledgment of the welcome given to them by the Prince of Wales was made by Sir Joseph Cook on behalf of the Dominions, by Mr. Guido Semenza for the European countries, by Dr. M. Kamo for Japan and by Mr. O. C. Merrill as representing the United States and the South American countries.

On Monday evening the dinner of the conference was held in the Queen's Hall, Langham Place, London, when the Right Hon. the Earl of Derby, K.G., presided over a company numbering 750.

When proposing the toast of "The First World Power Conference," Lord Derby said that the work of organising the conference had been an immense task and reflected the greatest credit on Mr. D. N. Dunlop and the committee. From their deliberations a fund of knowledge would be made available which would be useful to the whole electrical world. No great industry could afford to regard their decisions with indifference. The railways would have to consider whether they could not reduce their charges for freight, and manufacturers had to devise methods of reducing costs of production. It might as the results of their labours be possible to establish principles capable of international application and further development in the future. Replies were made by M. Arbelot, Vice-Chairman of the French Committee of the Conference; by Mr. F. V. Hansen, the Chairman of the Swedish Committee; and by Mr. Samuel Insull, Vice-Chairman of the United States Committee. Mr. S. Z. de Ferranti proposed the toast of "The Guests," to which response was made by Mr. Frank Hodges, M.P., Civil Lord of the Admiralty, by Mr. J. G. Bellaar Spruijt, of the Netherlands, and by the Hon. Sir James Allen, K.C.B., High Commissioner for New Zealand.

THE POWER RESOURCES OF THE BRITISH EMPIRE AND THE UNITED STATES OF AMERICA.

At the first session for the consideration of papers held on Tuesday morning in the Conference Hall of the British Empire Exhibition, Sir John Snell, Chairman of the Electricity Commissioners, presided,

and in his opening remarks referred to the unique character of the gathering. It was, he said, the first occasion on which the principal authorities on power production had been brought together to discuss questions of national and international importance. The interchange of ideas would make for progress in the conservation and proper utilisation of the resources of the world. They had a duty to do as acting for the generations yet to come. They should not be content with a partial development of water power nor should they accept a consumption of 3 lb. of coal per kilowatt hour when it was possible to obtain a figure of something slightly more than half of that. The multiplication of periodicities used in supply systems in Britain had acted as obstacles to the fulfilment of unified and economical systems of working. They welcomed the great authorities of the world to the conference because they believed it would have an educative effect upon the people. Possibly the adoption of a more satisfactory way of working, one worthy of the times, would be accelerated by the work they did in conference.

Sir Richard Redmayne, K.C.B., presented his paper on the Coal Resources of the World, a short abstract of which is reprinted in this issue, page 31. One thing that was wanted, he said, was a chemical survey of the coal resources, which as far as Britain was concerned, was now being undertaken by the Fuel Research Board. He concluded with the statement that in his opinion coal held the field as the general source of energy, and would continue to do so for many centuries. It should be consumed so as to utilise the whole of its potential energy. All else was waste. The means were available, and if the theoretical problems involved could be translated at once into commercial facts the whole aspect of the fuel question would undergo an amazing transformation.

Mr. Russel Sinclair then submitted the report on the Power Resources of the Commonwealth of Australia and the Mandated Territory of New Guinea, an abstract of which is given on page 31. Mr. W. H. Taylor followed and supplemented the remarks of Mr. Sinclair by references to Western Australia. They had, he said, a great amount of fuel refuse from the forests, but had not yet found the means to utilise it on a large scale. They were in the fortunate position of starting with new territory and could place their generating stations wherever they wished and could take advantage of the experiences gained in the Mother Country.

Professor A. H. Gibson followed with a review of the water power problems of Great Britain and Ireland, which is referred to in our abstracts of the papers on page 31. There were great troubles with small schemes as private Bills were necessary to get powers to proceed. The first sign of interest was shown when the Conjoint Board of Scientific Societies formed a water power committee in 1917. This was followed in 1918 by the formation of a Board of Trade Committee under Sir John Snell. A lively interest was now taken by the Government in tidal power and it was probable an enquiry would be held into the resources of the Severn.

Mr. O. C. Merrill, U.S.A., presented a "National Review of Power Resources," compiled by Messrs. N. C. Grover, M. R. Campbell and himself. In this it was stated that the dependence on coal and the geographical location of the coal mines fixed the positions of the main industrial activities of the United States within the north-eastern section and over 50 per cent of the bituminous coal production was used in the five States of New York, Pennsylvania, Ohio, Indiana and Illinois. Over three-quarters of the prime mover capacity of the United States employed in manufactures, central stations and electric railways was found east of the Mississippi River. There were in America 3,200 water power plants of 75 kilowatts and more, having a total capacity of 6,778,871 kilowatts, an increase of 15 per cent. over the total in 1921. Of this, 81 per cent. was used in public utility plants and the remainder in manufacturing concerns. The potential resources amounted to 25,975,000 kilowatts available 90 per cent. of the time and 41,052,000 available for half the year. The estimated coal reserves amounted to 1,560,000,000,000 tons of which 17½ per cent. was lignite, 29 per cent. sub-bituminous coal, 51 per cent. bituminous coal and the remainder semi-bituminous coal. Oil reserves amounting to 10,045 million barrels were also available.

Mr. Fred A. Gaby spoke on the water power resources of Canada, which was treated as a section of the voluminous report presented by Canada, some particulars from which are given on page 31.

Mr. John W. Lieb, U.S.A., epitomised the report he submitted on the North-Eastern States and also that of Mr. Samuel Jasull on the Central States. In the former it was stated that the kilowatt hours generated per head of population was 624 as compared with 509 for the whole of the United States. But the kilowatt hours produced per square mile were 96,620 as compared with 18,800 for the entire country.

In 1922 the total kilowatt hours supplied by central stations in the North-Eastern States was about 15,876,000,000 and the installed plant was of 5,838,000 kilowatt capacity. The annual rate of growth was between 10 to 15 per cent. With the growth of the power market there was shown a steady movement to increase sizes of plants and to make interconnection between otherwise independent systems. A large part of the water power in the district was located on the Niagara and the St. Lawrence River at the international boundary. It was estimated that six million horse-power could be developed at Niagara and there were also possibilities of no less than five million horse-power on the St. Lawrence. Much of the other water power resources required large reservoirs to overcome the wide variations in stream flow.

The Central States furnished over 45 per cent. of the total output of bituminous coal, 51 per cent. of the crude petroleum and over 45 per cent. of the timber produced in the country. Nearly all of the water powers of the Mississippi were of such a character as to require for constant service in supplying energy a reserve steam plant of nearly equal rating. In some instances the magnitude of the capital necessary for water power development made economic working impossible.

Mr. E. Parry referred to the New Zealand paper prepared by Mr. Lawrence Birks, which is abstracted on page 31, and Mr. Haanel dealt with the fuel resources of Canada, which is also epitomised on the same page of this issue. Mr. J. Willoughby Meares (India) followed, and suggested that as Canada had now adopted a definite basis for water power on ordinary minimum flow as well as for maximum development, they now had an example which might well be followed. The conference would do valuable work if it settled a basis for general use. Conditions of rainfall varied widely in the different countries, but he thought it might be possible to devise a standardised method. He also called attention to the dissimilar use of the word billion by various speakers. Colonel Batty, of the Punjaub, called attention to the possibility of creating great natural lakes by using rock-filled dams in canyons, The transmission system was the vital consideration in a power scheme. When it could be afforded, it was advisable to put down the biggest transmission system possible.

Mr. Robert Sibley, of California, then spoke on the "Review of the Power Resources, Distribution and Utilisation in the Pacific Coast States of America." Within the states of Washington, Oregon and California he said, was located 43 per cent. of the total potential water power of the United States, amounting to 16,000,000 horse-power. The schemes in operation had a capacity of 1,390,000 kilowatt, and further extensions, amounting to 410,000 kilowatt, were in course of construction. The total steam power produced was 566,700 kilowatt, which will shortly be extended to 694,200 kilowatt. The interconnection of the systems on the Pacific coast was accomplished many years ago. This permitted the more complete use of the hydraulic resources and reduced to a minimum the quantity of steam generated and kept down the magnitude of reserve plant. There are 30 interconnected stations in California generating at 66,000 volts, the largest of which has a capacity of 25,000 kilowatt.

Dr. George Otis Smith (U.S.A.) said that much of the coal and oil of the United States was found in the sparsely populated parts of the country. This real handicap might in the future be overcome. They had still to look upon coal as the greatest source of power. In many parts of the world the growth of utilisation of water power was not keeping pace with coal because of the need of great capital resources for its development.

Mr. David B. Rushmore (U.S.A.) spoke about the benefits to mankind that might accrue if engineers who had shown much ability in dealing with physical forces would devote some of their time to political affairs. The estimate of the usefulness of the organisation of the World Power Conference by Mr. D. N. Dunlop was well nigh impossible, and it should be maintained for the frequent discussion of their affairs in common. Mr. Armfield referred to the cheapness of water power installations of small capacity, and Mr. W. S. Murray (U.S.A.) said the most important thing in regard to power was its existence and the cost was of secondary importance. Power only cost 4 to 5 per cent. of the total for any manufactured product. Sir John Snell then closed the morning session and the meeting was adjourned.

The Power Resources of European, Asiatic and South American Countries.

On Tuesday afternoon the meetings were resumed under the chairmanship of Dr. George Otis Smith, Director of the United States Geological Survey. In his opening remarks the chairman referred to the great value of pooling information on their experiences, in promoting the common welfare. He then called upon the speakers in the alphabetical order of the names of their countries.

Mr. Oskar Taussig of Austria referred to the limited resources of coal possessed by his country. It was estimated that these would be exhausted within a century. They had to concentrate on water power and appreciated the help given by Britain and America in developing the resources. The capital cost for each horse-power of water power was 50*l.* in Austria. Mr. Emile Uytborck, in presenting the Belgian report, said that the prosperity of the country largely depended on the presence of a comparatively large coalfield. From this 22,000,000 tons were raised per annum. A new coalfield was in process of development, from which it was anticipated 8 to 10 million tons of gas coal would be raised every year. Windmills, which were largely used in Belgium in former days, were entirely replaced by electric motors.

Dr. Ivan Zmavc specified 1,750,000 h.p. as the magnitude of the water power resources of Czechoslovakia, of which 150,000 h.p. was in use. The economic development of their power resources implied complete electrification of the country. Mr. O. V. Morch said Denmark had presented a paper to show what had been done in a very flat country. The work was undertaken to find useful employment during the recent testing times. Professor F. K. van Iterson then presented his report on Holland, of which an abstract is given on page 32, and was followed by Mr. Wouter Cool, who spoke about conditions in the Dutch East Indies, to which reference is made on page 33 of this issue.

For France M. Arbelot and M. Guillaume spoke, and from their remarks it was apparent that railway electrification had been pushed on because of the high price of fuel, the use of which was being superseded by water power. The Paris–Orleans line used the power of the Massif Central, while the P.L.M. was working on supplies from the Alps, and the Midi was exploiting the resources of the northern slopes of the Pyrenees. The actual water power available in France was about 6 million kilowatts, one-sixth of which was already in use. They had much inferior coal in France and, although it contained 35 to 40 per cent. of ash, it was burned in the pulverised state in central stations with success.

After the Hungarian position, referred to on page 32, had been dealt with, Mr. Norsa said Italy had very limited coalfields and the product was poor. They had in consequence to rely on water power obtainable from the Alps and Appenines. Horse-power to the extent of 2,000,000 was obtained which represented about one-quarter of what could be developed. New developments to extend the use of water power were in process of construction. Mr. Inouye then presented the Japanese report, Mr. S. Kloumann that of Norway and Mr. W. Borgqvist spoke for Sweden. Abstracts from these reports appear on pages 32 and 33. The conditions in

Poland were then referred to by Mr. K. Straszewski, and those of Spain by Mr. G. Quijano, after which Dr. E. Tissot presented his report on Switzerland (see page 32). It was stated by Mr. Prikril that the development of the power resources of Yugo-Slavia was impossible without the assistance of foreign capital. The meeting was then adjourned.

The further proceedings will be dealt with in succeeding issues of ENGINEERING.

THE ROYAL AGRICULTURAL SHOW AT LEICESTER.

THE eighty-third annual show of the Royal Agricultural Society of England was opened last Tuesday at Leicester. This is the third time that Leicester has been chosen as the scene of this important exhibition, the previous occasions being in 1868 and 1896, an interval of 28 years again elapsing before the present visit. The show-ground, which is 140 acres in extent, is only a mile from the centre of the City, so that access is easy and everything promises, at the time of writing, the success which the Society so well deserves on account of its services to British agriculture. The livestock entries amount in the aggregate to 3,975, a number which has only twice been exceeded, namely at Cambridge in 1922, when the number was 4,200, and at Windsor in 1889, when the total was just one more than on the present occasion. It should, however, be mentioned, that a considerable number of entrants have not put in an appearance owing to restrictions on transport due to foot and mouth disease. The exhibits of machinery and implements, with which alone we are concerned, are not quite so many as in previous years, the 11,697 sq. ft. of shedding, exclusive of open ground space provided at Leicester, marking a continued annual decline from the record area of 14,494 sq. ft. at Darlington in 1920. This we fear reflects the adversity which has befallen not only the agricultural machinery industry but engineering in general during the past few years. The simultaneous exhibition at Wembley has also had its effect in curtailing the exhibits at Leicester, but in spite of all unfavourable influences, to the ordinary observer, the show this year appears to present the same variety and interest as ever, any shrinkage in exhibits being noted more by the absence here and there of a familiar name, than by any sense of incompleteness.

Regarding the Show as an index of the mechanicalisation of agriculture, it cannot be said to point to any particularly new development. Possibly there is little scope for such. There is now hardly an operation of any kind on a farm or an estate for which some kind of machinery is not available, and the task of the manufacturer is now either to improve and cheapen his products until they are indispensable for commercially economical work or to convince the farmer that they are already so. This is particularly applicable to the agricultural tractor of which so great a sphere of usefulness was prophesied. Plenty of tractors are to be seen at Leicester, but they arouse less interest than might be wished and it appears unlikely that there are as many sold annually or in actual use as there were a few years ago. The greatest novelty in the tractor line to be seen at Leicester is undoubtedly the new Rein-drive tractor, exhibited in action by Messrs. John Fowler and Company (Leeds) Limited of Leeds. This, machine, which is of Australian origin, is a sort of mechanical horse. It has two road-wheels only and is coupled rigidly to the plough, reaping machine, or what-not that it has to pull. The driver sits back on the pulled machine, away from the noise and smell of the tractor, which he drives by a pair of leather reins only. With the reins held in the left hand as a rider holds them, the tractor can be started, stopped, backed or steered in either direction by the manipulation of the reins alone. Steering is effected by power, and the turning of the tractor is independent of whether it is going forward, or backward or is stationary. A slight turn of the wrist in either direction tightens the corresponding rein and brings a friction pulley into contact with the rim of the flywheel, and so operates the steering mechanism. A slight jerk on the reins puts the tractor into forward gear. A steady pull on the reins stops the tractor and puts on the brake. A further pull introduces the reverse gear. The reins are never loosened in the hand during the manipulation of the machine, and the right hand, being neither required nor used, is free to attend to other duties.

EXHIBITS AT THE ROYAL SHOW AT LEICESTER.

CONSTRUCTED BY THE SENTINEL WAGGON WORKS, LIMITED, SHREWSBURY.

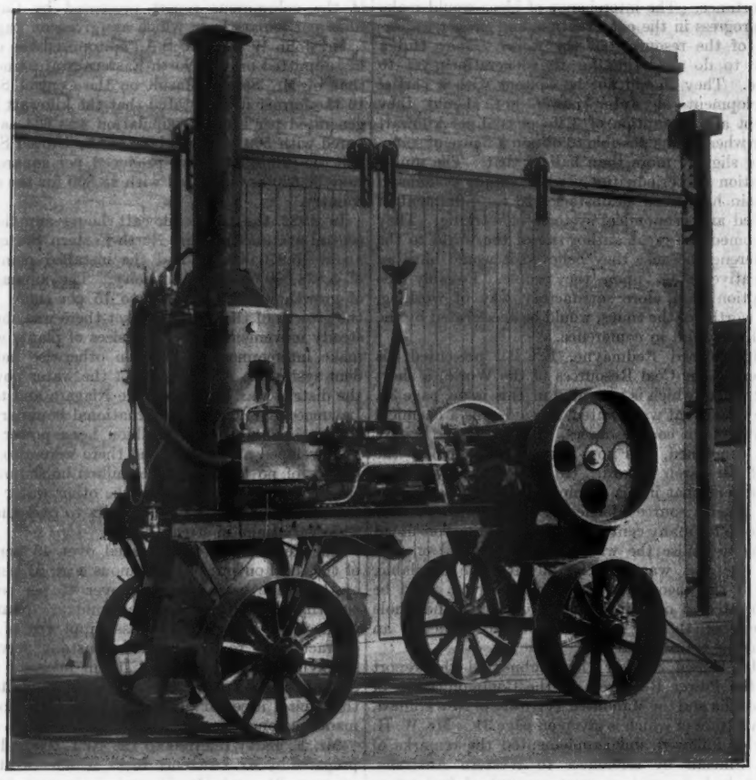


FIG. 1. PORTABLE STEAM ENGINE.

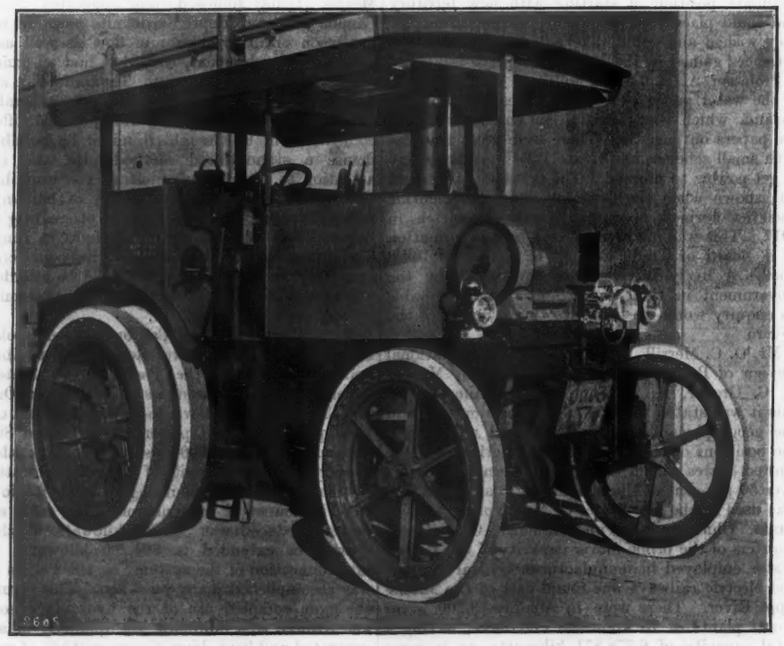


FIG. 2. STEAM-DRIVEN TRACTOR.

The Rein-drive tractor is fitted with a 30 brake horse-power V type paraffin engine, having two cylinders 5½-in. bore by 7½-in. stroke. The driving wheels are of cast steel 40-in. diameter and 11-in. face, fitted with easily removable rocking pads to

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW AT LEICESTER.

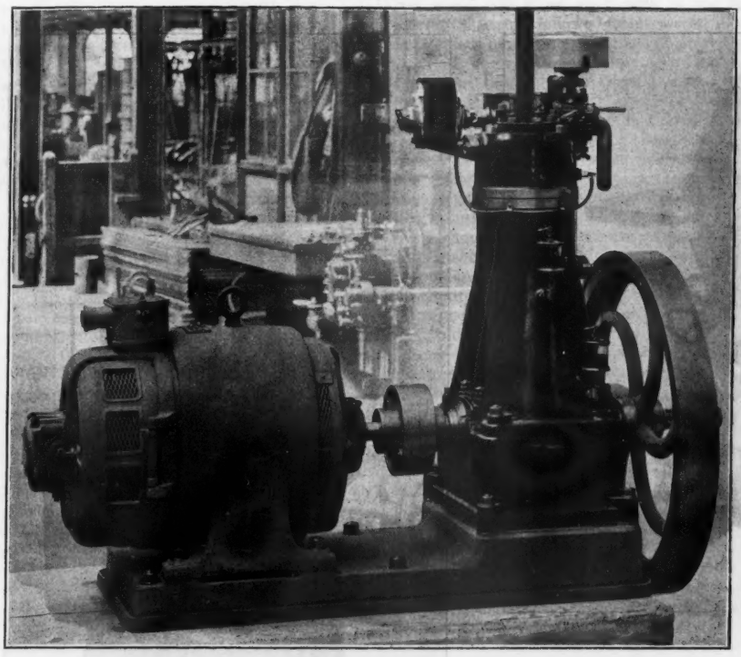


FIG. 3. SMALL ELECTRIC LIGHTING SET; THE NATIONAL GAS ENGINE CO., LIMITED, ASHTON-UNDER-LYNE.

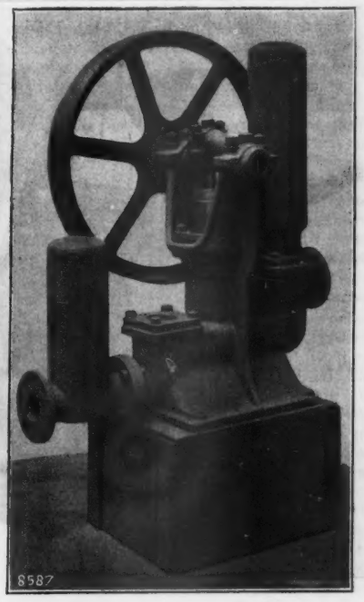


FIG. 4. VERTICAL RAM PUMP; MESSRS. TANGYES, LIMITED, BIRMINGHAM.

relieve the ground-pressure. Each tractor has a trailing truck to which it is coupled when not in use for other purposes. The truck has 30-in. wheels, 6 in. wide and will carry a load of 2 tons. The tractor will pull a three-furrow plough, or any equivalent load. It is a highly ingenious machine which can be manipulated with extraordinary ease, and the unrivalled experience of its makers in the requirements of agricultural machinery gives assurance that it is unlikely to fail on account of any mechanical deficiencies.

For some years the practically complete absence of the portable steam engine, which was once the main source of power for thrashing, chaff-cutting, &c. on a farm, has been noticeable at the Royal Show. The portable engine seemed to have been supplanted by the tractor or the oil engine, and at one of the recent shows we believe that only one portable steam engine was to be seen. This year three makers are showing the once familiar type, but a more enterprising bid on behalf of steam is to be seen in the new portable engine exhibited by the Sentinel Waggon Works, Limited, of Shrewsbury. It embodies radical changes in every respect, from the locomotive type boiler on wheels surmounted by an open type engine which was characteristic of the old portable. The Sentinel Company have taken the vertical boiler and the horizontal totally enclosed poppet valve engine which have both proved so successful in the severe duties of the Sentinel steam wagon, and have mounted them on a wheeled framing of steelwork. Both are absolutely standard, the only difference from steam-wagon practice being that the boiler has a large firebox into which any desired solid fuel can be fired from the side, and the engine has a pair of flywheels and no differential. The steam pressure is 200 lb. per square inch. The portable engine is illustrated in Fig. 1 on page 20. There is no reason to doubt the claim that it is decidedly more economical in fuel than the usual portable engine, and as both the boiler and engine are of well-proved design, the satisfactory operation of the engine may be taken for granted. The engine will develop 55 brake horse-power, and is said to require only 20 lb. of steam and 3 lb. per coal per b.h.p. hour. The weight of the vehicle in running order is 85 cwt.

Besides their portable engine, the Sentinel Company are showing the tractor illustrated in Fig. 2. This again embodies the standard engine and boiler of the makers, mounted on a very short chassis, and the tractor is claimed to do everything that the ordinary agricultural tractor will do, with the added advantages of the smoothness of operation and the economy of fuel associated with the use of steam. The two productions of the company which we have illustrated are noticeable as well-considered efforts to bring back steam to the position it once held, and to provide users with engines the operation of which is not dependent upon the use of imported fuel. From this point of view alone the enterprise of the makers is to be commended.

One of the interesting questions upon which the successive Royal Shows throw light, is the displacement of steam by petrol, paraffin or crude oil for agricultural purposes. The stationary steam engine seems to have vanished entirely, its place being taken very largely by crude-oil engines either of the hot-bulb two-cycle type or the more recent four-cycle cold-starting type. The rivalry between these engines is keen, and though the latter kind is of more advanced design and more economical of fuel, the lower compression and greater simplicity of the former give it a very strong position. Messrs. Fielding and Platt, Limited, of Gloucester, have, we believe, abandoned the high-compression cold-starting type in favour of a four-cycle hot-bulb engine with which they have been most successful, but on the other hand, Messrs. Ruston-Hornsby, Limited, of Lincoln, The National Gas Engine Company, Limited, of Ashton-under-Lyne, Messrs. Crossley Brothers, Limited, of Openshaw, Manchester, Messrs. Tangyes, Limited, of Birmingham, and other firms are actively engaged on the development of the cold-starting engine. So far as one can see, the hot-bulb engine is likely to hold its own for a long time to come for small and medium powers, the high-compression cold-starting type being preferred for larger powers, where reasonable attention is available and where fuel of the cheapest grade has to be used.

The engine illustrated in Fig. 3 represents a design manufactured by the National Gas Engine Company, which with suitable modification will burn any fuel whether town or producer gas, petrol, alcohol or paraffin. The engine is built in two sizes, the smaller developing 4 brake horse-power at 600 r.p.m., and the larger 7 brake horse-power at 530 r.p.m., both ratings being with petrol as fuel. A throttling governor and a high-tension magneto are fitted. The frame is of "A" pattern, generally similar to that adopted for small steam engines, and the main bearings are ring lubricate. The crank-shaft is machined all over, the crank-pin being lubricated by a "banjo." The cylinder-head carries the inlet and exhaust valves in cages, and is well water-jacketted. The cylinder itself is provided with an easily renewable liner of hard cast iron. The water-jacket of the cylinder is formed by the upper part of the cast-iron frame. In addition to this engine the National Company are showing an example of their horizontal engines with a chain-driven dynamo, for country-house lighting. These are built to give from 1 kw. to 7 kw., and are supplied complete with batteries and switchboards These engines can also be supplied to run on gas, petrol or paraffin oil, and the dynamos and batteries are suitable for 25, 50 or 100-volt installations. The single-cylinder cold-starting crude-oil engines of the National Company are built in sizes from 18 to 83 brake horse-power. The example on the stand is rated to develop 30 brake horse-power at 250 r.p.m. These engines are of the horizontal open type, and by duplicating the cylinders in each case an engine of double the power is obtained.

Messrs. Blackstone and Co., Limited, of Stamford, are exhibiting a caterpillar tractor and an oil-driven locomotive, in addition to a large range of oil engines, but the greatest novelties on their stand are a cold-starting heavy oil engine, a 12 brake horse-power "synchro-balance" engine, and an oil-driven cable ploughing engine. The principal feature of the Blackstone cold-starting engine is the method of injecting the fuel oil. The fuel is injected by means of a spring plunger, composed of two members with a spiral spring between them. To one end of this plunger fuel is delivered by a governed pump. This fuel moves the whole of the plunger with its spring, bodily outwards, so that the pump does not have to work against pressure. The spring of the plunger

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW AT LEICESTER.

CONSTRUCTED BY MESSRS. WADKIN AND CO., ENGINEERS, LEICESTER.

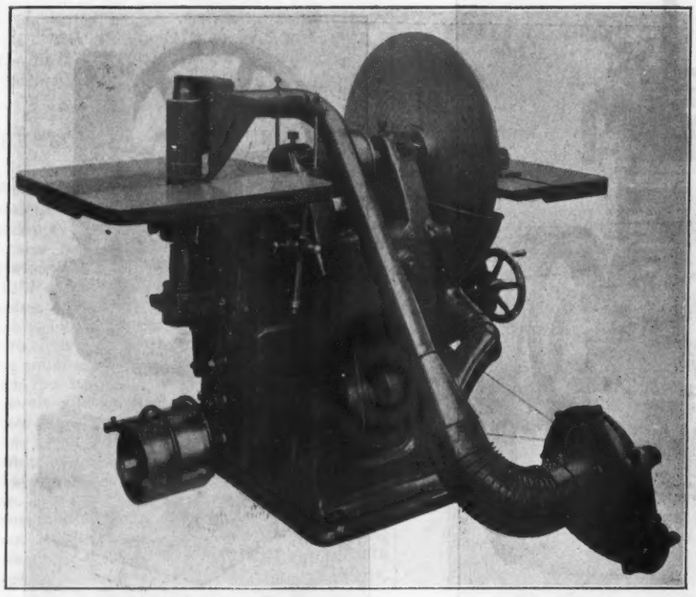


FIG 5.

FIG. 6.

FIGS. 5 AND 6. DISC AND BOBBIN SANDER.

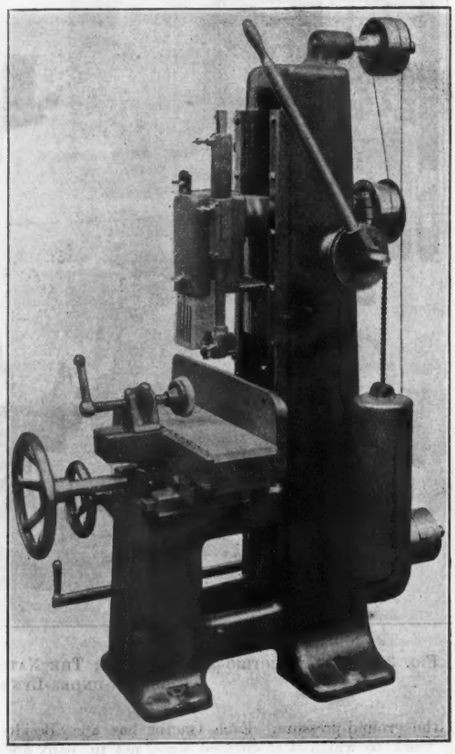


FIG. 7. CHAIN MORTISING MACHINE.

is then compressed by a lever acting upon the outer plunger member, the inner member being held by abutting on the fuel which is retained by the spraying valve. At the inner end of its travel the lever relieves the closing spring of the spraying valve, allowing the pressure of the fuel to open this valve, when it is injected into the cylinder by the plunger spring. The advantage of the arrangement is that the fuel is injected at the same pressure and speed whether the engine is running at its normal speed or is just starting. The engine works with a compression of only 350 lb. per square inch, and the initial pressure at full load is 550 lb. per square inch. Starting is effected direct from the cold condition with the fuel on which the engine is to run, no preliminary injection of petroleum being ever needed. Single-cylinder horizontal engines of the type referred to are built in sizes from 4 brake horse-power to 150 brake horse-power, and multi-cylinder engines up to 900 brake horse-power. We need not give further particulars of these engines at present as we hope to illustrate them shortly. The same remark applies to the extraordinary "synchro-balance" engine of Messrs. Blackstone, an example of which rated at 12 b.h.p. is shown on the stand. In this engine the crankshaft is well to one side of the vertical centre-plane, and the crank pins are at an angle of nearly 40 deg. to the axis of the crankshaft, so that they have a kind of conical motion. It would be quite impossible to describe the mechanism of the engine intelligibly without the aid of the drawings which we hope to publish in due course, and the matter must stand over till then. It must suffice now to say that the "synchro-balance" engine is much smaller and lighter than the conventional type of petrol-engine, the angularity of the connecting rods and the consequent side-thrust is practically negligible, and the weight of the reciprocating parts is much reduced.

The pumps to be seen at the Show are as usual extraordinarily numerous. Centrifugal, rotary, reciprocating and diaphragm pumps are represented in a wide variety of sizes and types. Messrs. Drummond Brothers, Limited, of Guildford, show a very neat little geared ram-pump, and other ram pumps with and without gearing are plentiful. The pump illustrated is Fig. 4, is shown by Messrs. Tangyes, Limited, of Birmingham. It is made in three sizes, which will deliver 460, 1,050 and 2,100 gallons per hour respectively, against heads up to 150 ft. when driven at 90 r.p.m. The rams are of cast iron, and the valves are of india-rubber with brass guards and seats, and spindles of Muntz metal. The connecting rods are of steel, with brasses at each end. As will be seen in the illustration large air vessels are provided both for suction and delivery. Another water-raising device which deserves mention is that of Messrs. Boulton and Paul, Limited, of Norwich, in which an endless belt of special construction picks up the water and raises it continuously to any required height, when it is discharged by centrifugal force as the belt passes round the upper pulley. The device is remarkably efficient and the absence of any valves, and the freedom from possible damage by gritty water, &c.,

make it very serviceable. Many examples are shown on the makers stand, the water-lifter being often arranged to discharge into a high-lift centrifugal pump which delivers the water against pressure.

At all the shows of the Royal Agricultural Society, certain manufacturers take the opportunity of exhibiting machinery which has no appreciable connection with agriculture. This year Messrs. Wadkin and Co., of Green Lane Works, Leicester, have taken the advantage of the presence of the show in their own city to exhibit a large range of wood-working machinery. The machine we illustrate in Figs. 5 and 6, on page 22 is a disc and vertical bobbin sander of the firms latest design for the requirements of the pattern-shop. At one side is a 30-in. sanding disc running on a horizontal spindle, and at the other side is a bobbin 3½ in. diameter and 9⅜ in. high on a vertical axis. Two operators can use the machine at the same time, and by its aid wood may be reduced to almost any conceivable shape. The disc work-table is arranged to cant to 45 deg. below and 15 deg. above the horizontal, and can be locked where desired. A scale gives the principal angles and a plunger stop registers the horizontal position. The table is grooved to receive a universal swivel fence, and it has also a horizontal adjustment, by means of a handwheel, to and from the disc. Holes are provided in the table to receive a centre-pin, by the aid of which circular work can be sanded. These holes, in combination with the horizontal adjustment of the table, enable extremely accurate work to be done. The vertical sanding bobbin is carried in a sliding frame which is arranged to reciprocate vertically, thus giving a smooth finish to the work. The bobbin spindle runs in ball bearings.

The bobbin table can be canted up to 30 deg. below and 15 deg. above the horizontal, and may be locked in any position, the horizontal being registered by a plunger stop. The table is arranged with adjustable plates to enable various sizes of bobbin to be used. The bobbin reciprocating motion is obtained from a crank and connecting rod arrangement driven by totally-enclosed reduction gearing from the main shaft, which is arranged in the base of the machine. A motor drive by means of belt or enclosed chain can be provided if desired, and a self-contained dust-removing arrangement, as shown in Fig. 5, is also available. The dust is collected from the disc by a bottom hood and from the bobbin by another hood, so shaped that the bobbin table may be canted without interference with the efficient action of the apparatus. The machine will accommodate bobbins from 2 in. to 5½ in. diameter. The disc table is 34 in. by 17 in. and has a lateral adjustment of 3 in. The table is 35½ in. above the floor level. The bobbin table is 26 in. by 25¾ in. and is 37½ in. high. The whole machine occupies a floor space 5 ft. 4 in. by 2 ft. 10 in. and weighs 16 cwt. net. It requires 6 h.p. to drive it to its full capacity.

Messrs. Wadkin and Co. are also exhibiting the chain mortising machine with square hollow chisel attachment, illustrated in Fig. 7. The machine is entirely self-contained, with its countershaft in the base. It will take timber up to 12 in. by 8 in., and will cut a mortice, using the chain, of 1¼ in. by 3 in. by 6 in. deep. The maximum size of chisel that can be used is ¾ in. broad. Ball bearings are fitted to both chain and chisel spindles. An efficient guard, made to conform to the Home Office regulations rests on the timber during the cutting operation, and being hinged, it affords easy access to the chain when desired. An adjustable chip-breaker prevents any tendency for the top edge of the mortice to be injured. A chain cutter grinder is included with the machine. The chain is mounted on a sleeve, which is arranged to suit various sizes of chains, and slides on a bar backwards and forwards past the grinding wheel. Automatic stops are fitted to facilitate rapid and accurate work. The size of the table is 24 in. long by 8 in. wide, and it is 27 in. above the floor level. It has a longitudinal motion of 22 in. and a transverse motion of 4½ in. The net weight of the machine is 8 cwt., and it requires 3 b.h.p. to drive it. When a belt drive is used, the speed of the driving shaft is 1,000 revs. per minute.

(To be continued.)

INSTITUTION OF GAS ENGINEERS.

MANY of the reports and papers submitted to the meeting of the Institution of Gas Engineers held last week, which we dealt with in our last issue, on page 834, were followed by interesting discussions. Particulars of some of these are given below.

Mr. E. V. Evans gave a summary of a communication from the South Metropolitan Gas Company, explaining the company's laboratory enquiry into the catalytic synthesis of methane from carbon monoxide and hydrogen, with the object of removing carbon monoxide from water gas and coal gas. In fact, the research up to date showed that the velocity of the reaction can be increased seventeen-fold by using activated nickel-thoria as the catalyst, but although a technical process had been worked out, the cost, not only of maintaining the proper proportion of carbon monoxide and hydrogen for the hydrogenation reaction, but also of removing sulphur compounds with the completeness necessary to avoid poisoning the catalyst, would make the process too expensive for use in the gas industry. The removal of the sulphur compounds from coal gas, moreover, would involve partial elimination of valuable unsaturated hydro-carbons and also the conversion of part of the carbon monoxide to carbon dioxide—a gas useless for combustion—besides an appreciable further loss through the exothermic nature of the hydrogenation reaction. The method used for at once increasing the concentration of hydrogen and removing sulphur compounds, to which the above objections applied, was to pass gas, in the presence of steam, over an iron-chromium oxide catalyst at 550 deg. C. The removal of sulphur was carried to a figure below one part per 1,000,000 parts of gas, which was considerably higher than is necessary for ordinary purposes, but was indispensable in the use of the catalyst.

Professor J. W. Cobb submitted a report of the Research Sub-Committee of the Gas Investigation Committee on waste heat boilers and vertical retort installations. The experiments were conducted on plant placed at the disposal of the Committee by the Birmingham Gas Department. The waste heat boilers which were connected to an installation of vertical retorts operating under the usual conditions of works practice, evaporated about 40 lb. of water for 100 lb. of coal carbonised, or 3 lb. of water per lb. of coke to the producers. Dr. Parker, the Research Chemist in charge of the investigations, gave a summary of the report. Mr. J. S. Thorman laid stress on the importance of keeping the hardness of the feed water as low as possible; in the Birmingham experiments it was only 5 deg., but for a high evaporation from a limited surface he preferred zero hardness. He also preferred fire-tube to water-tube boilers, of which he had had no personal experience, not only for their efficiency but also because of the convenience of cleaning them while the boiler is at work. In the plant in his own works he had occasion to note the great importance of the velocity with which the gases passed through the tubes.

With all the tubes at work he had, for example, an evaporation of 3·85 lb. per square foot per hour, whereas with one-third of the tubes stopped, the evaporation increased to 5·07 lb. With zero hardness of water, without cleaning, observation or attention, his plant ran night and day for seven months with a loss of efficiency of only 6 per cent. He saw no reason why the use of waste heat boilers should be restricted to water gas plants or vertical retorts and not extended to horizontal plant. The report confirmed his belief that the use of waste heat boilers could provide more than enough steam for all the purposes of a gas works.

Mr. J. P. Leather confirmed the view that by using waste heat boilers a gasworks could obtain all the steam and power it required and have steam to spare to sell to someone else. Mr. G. C. Pearson said that the waste heat boiler installation at the works at which Dr. Parker's investigations had been carried out was not according to the best modern practice, and better results would have been obtained at the Corporation's new Nechells works. Even with water of the moderate hardness of the Birmingham supply, water tube boilers are found to give so much less trouble than fire tube boilers that, although the latter are more efficient, they cannot be used in practice without putting down a softening plant.

Even at Windsor Street works, where the experiments were made, there was more than enough steam for all purposes—running the works, steaming all the verticals, and running two water-gas plants—and a boiler could be shut down when desirable without serious consequences.

Mr. A. G. Lane's paper describing results obtained from a Travers-Clark regenerative coal gasification plant at Aylesbury, was accompanied by communications from Dr. Travers and Mr. Clark, indicating how and to what advantage the system works. Dr. R. Lessing, repeating what he had said some years ago in another connection, believed that the richness of the gas in hydrogen would tend to control the splitting up of hydrocarbons and to preserve their thermal value. The circulation process was closely analogous to one that had been used successfully in America on oil, and its results were encouraging to the prospects of the Travers-Clark system. Mr. R. G. Shadbolt, while welcoming the paper and the communications of Dr. Travers and Mr. Clark as likely to lead to progress both in practice and theory, quoted a plant of which he had had experience for four and a-half years, which gave complete gasification at much the same rate as the process described in the papers, and urged enquiry into the question of whether the added complication of regenerative action gave any corresponding gain. Mr. H. Robinson gave particulars of an alternative complete gasification plant, from which results similar to those of the author were obtained from horizontal retorts worked on an entirely different system, and apparently at a less expense for labour. He urged that the economy and convenience of avoiding the need for quenching coke, and of controlling the quality of the gaseous product merely by shutting off steam when required, was an established advantage of complete gasification. Mr. W. M. Carr, while quoting another installation in which efficient heat transference was obtained by making the fuel travel mechanically through a retort, expressed the opinion that the Aylesbury plant was a distinct advance, and carried further than before the principle of transferring heat directly instead of by conduction through the walls of a retort. Mr. Lane, Dr. Travers and Mr. Clark replied, the latter pointing out that the several operations necessary in the process were performed by a valve on the cold gas, without the use of any hot valve at all.

Mr. W. Emery gave a summary of his paper on refractories for gas retorts with special reference to silica, and Mr. Leather introduced the report of the Refractory Materials Joint Research Committee, a joint discussion being held on the paper and the report.

Among the several subjects included in the communications from the British Refractories Research Association, on which the Committee's report was based, was one by Mr. A. J. Dale, giving the first part of an investigation into the relation between chemical and physical combustion and ordinary and under-load refractoriness.

While on the whole fire clay bricks continue to be the most important refractory, increasing attention is being given to silica bricks. This term is used rather loosely, and, according to the Institution's classification, includes all materials containing over 92 per cent. of silica; those of which the silica lies between 80 and 92 are classed as siliceous. Messrs. Hugill and Rees gave the first part of a study of the effect of repeated burning of lime-bonded silica bricks, made, in fact, from Sheffield ganister, the result being to show considerable increase of strength following on prolonged burning. A paper was read on the first part of the investigation by Dr. J. W. Mellor on causes of variation in the sizes of bricks, from which it appears that the best maturing temperature for a firebrick varies with the fire clay, and is that at which a further rise of temperature produces insignificant changes of volume when the fire brick is heated to the highest temperature at which it is likely to be used. When the contraction-temperature curve shows no such point, the sizes of bricks will be liable to vary.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.

THE Institution of Municipal and County Engineers held its fifty-first annual meeting in London last week, its proceedings having commenced on Wednesday, the 25th ult., with the annual general meeting held at Croydon. At this meeting, Mr. G. F. Carter, Borough Engineer for Croydon, was installed as president for the ensuing year, and delivered his address. Various visits were paid in the afternoon and on Thursday, while on Friday, the whole of the morning and afternoon was devoted to the discussion of papers. On Saturday last there was a visit to the British Empire Exhibition and a meeting, when a discussion took place on the concrete construction adopted at the Exhibition. The visits on Wednesday were to the South Norwood sewage works and farm and the Croydon Aerodrome, and to Beddington sewage works and farm and Russell Hill Service Reservoir. On the Thursday visits were paid to the Metropolitan Water Board's Littleton Reservoir, and to the Great West Road and Kingston By-Pass Road.

In his address Mr. G. F. Carter said that the municipal engineers' duties were increasing in importance. What would have been a large contract in the past was now an ordinary event in their careers. The younger members should pay attention to proficiency in business matters, as their education could not be completed by examinations and office work without administrative and practical ability. The "business manager" should not be given the work of running departments which should be controlled by the engineer and surveyor. When emergency work had to be done value should be obtained for it, and no depreciation of standards should be permitted, as had occurred in housing schemes carried out by local authorities. Mr. Carter thought that if the State could see its way to interfere less in economic matters industry would be more likely to return to normal conditions. Their work as municipal engineers involved them in the clearance of insanitary slums, town planning, housing, baths, &c. Roads and sewage disposal claimed their attention. In connection with the former, a good road surface was now possible if a good foundation were constructed. Accommodation for services should be arranged under wide footpaths. Many carriage ways were being made of an excessive width and promised to be a burden on those who would have to maintain them. In sewage work decomposition, which was formerly avoided, was now encouraged as Nature's intended method of treatment. As regards water supplies, he thought a Government body should assist in securing and in fairly apportioning supplies between conflicting interests. Mr. Carter referred to run-off and percolation experiments conducted at Croydon on test gauges, one representing chalk on the Downs, and the other a gravel soil. With an average of 30 in. of rain over the area, the gauges showed 13½ in. passing through, while the gauging of the flow of the river, subsoil water and pumping corresponded to 11½ in. Tests had also been carried out to trace the flow of underground water in the district.

At the meeting last Friday, held at the Institution of Electrical Engineers, Sir H. P. Maybury delivered an address stating that new licences for motor vehicles continued to increase in number. The motor-car licences issued at the end of February last year numbered 274,151. The figure for the same date this year was 345,959. The total for motor vehicles had increased by 18 per cent. and for horse vehicles had decreased by 14 per cent. Although a great deal of progress had been made with regard to roads and bridges, Sir Henry thought it had scarcely been commensurate with this development of traffic, especially in districts contiguous to centres of population. The Road Fund revenue for this year would amount to about 15,000,000*l*. He was not in favour altogether of giving larger grants than at present, but thought it would be better to increase the number of grants instead. A penny saved in maintenance per square yard of all the classified roads in Great Britain would mean economy to the extent of 1,800,000*l*. per annum.

Four papers followed, the first to be taken being one by Mr. W. R. Manning, Borough Surveyor of Chelsea. The subject was "Street Traffic Regulation by Means of Coloured Signals," the author suggesting yellow or orange, green and red, with yellow to indicate caution without priority; green caution with priority, and red danger. These signals would be permanently displayed at road crossings showing which traffic should be given precedence.

Another paper was one by Mr. J. W. Green of Durham, who described the development of streets in that city from very early days and quoted a number of old authorities to bring out interesting points. Of more practical value perhaps was his description of the methods adopted of reconstructing many of the old and narrow streets, by continuous night and day work, provision being made for the passage of traffic in the meanwhile. Some of the streets taken in hand could not be closed owing to the absence of alternative routes. For much of this work Ciment Fondu was used with most satisfactory results, the paving being completed and the road opened to traffic within 24 hours of laying the last batch of concrete. The problem of bringing up supplies for rush work of this kind in narrow streets required very careful organisation.

The subject of "Oil Fuel and its Possibilities for Municipal Undertakings" was considered in a paper by Mr. R. H. Bicknell. This paper dealt with all the well-known systems of oil-fuel burning, the subject being sectionalised under three headings, viz.: the air jet system, steam jet system, and pressure jet system. Burners of various types were described.

The last paper was by Mr. John Howarth, who described the new works being constructed for the disposal of sewage at Sheffield. For some years Mr. Howarth has been conducting interesting experiments in connection with bio-aeration, employing mechanical agitation and aeration. The new plant being laid down provides ultimately for 14 aeration tanks of an approximate capacity of 900,000 gallons each. Two of these are completed and six others are in various stages of construction. The tanks are divided into 20 or 22 channels, each 6 ft. wide, in series, in which the sewage is circulated by means of paddles mounted on shafts driven by electric motors. The length of continuous channel in each section is about 5,540 ft. The wheels are 10 ft. in diameter and revolve at 15-16 r.p.m., the motors being of 45 h.p. and each shaft driving 21 paddles. Two shafts are mounted over each tank, revolving in opposite directions in order to provide for the reverse flow between contiguous channels.

INDUSTRIAL NOTES.

A JOINT MEETING of the executive committees of societies affiliated to the National Federation of Building Trades Operatives decided last week to instruct all building trade operatives to allow the employers' lock-out decision to take its course, as from to-morrow. Meanwhile, agreements were to be entered into with all available employers who were willing to agree, as a minimum, to the wages nationally negotiated on June 16. The National Allied Building Trades Employers, for their part, stated that in view of the request of the Minister of Labour, they were willing to receive from the operatives proposals designed to terminate the admitted breaches of the National Agreement in various parts of the country. The employers also alluded to the most unfavourable state of matters in Liverpool and other regions, adding that the only alternative open to them was to protect the interests of their members by withdrawing the suggested terms for settlement and passing resolutions to cease work. They further emphasised that their actions throughout had been governed by one essential factor, namely, the honouring of national agreements, to which all parties had given their signatures; it remained for the Operatives' Federation to see that their members carried out the obligations entered into on their behalf and so bring about an end to the dispute.

Both sides have had several interviews with Mr. T. Shaw, the Minister of Labour, but without any satisfactory result so far. There have, as yet, been no joint meetings of employers and operatives, the latter making it a preliminary condition that the lock-out threat shall first be abandoned, whilst the employers require that the Liverpool strike and other breaches of the National Agreement shall first be terminated. The Liverpool workers have hitherto declined to have their case decided by arbitration, or by a Court of Inquiry.

At the time of going to press an announcement is made to the effect that the employers have decided to postpone the posting of lockout notices until the 12th inst., following a statement by Mr. T. Shaw that he intends to appoint a Court of Inquiry and to use his influence to ensure that the findings of the court be published in eight days.

A meeting of all grades of commercial road-transport workers was held in London last Sunday, with a view to consider a new programme of wages and working conditions. The men demand a 10*s*. per week advance in wages. The meeting instructed the delegates to give one month's notice to the employers of the decision to have the present agreement revised.

The South Wales Miners' Federation at their conference held last week in Cardiff, have been considering the establishment of a trade union alliance of all workers engaged in productive industries. The prospect of unity with transport, railway and distributive workers generally was considered to be remote: on the other hand, it was recommended that the building, iron, steel, textile and other trades embodying productive workers should be invited to enter into alliance for placing simultaneously before employers new demands, minimum in character, and such as would not allow for compromise unless special sanction were obtained from the workers. It was recommended that the matter be considered by the Miners' Federation of Great Britain and by other bodies during a period of three months; if the response were favourable, a joint conference would be convened.

A resolution proposing that Mr. Thomas Richards secretary of the South Wales Miners' Federation, be censured for having recommended the miners to vote in favour of the owners' terms in the recent ballot, was defeated by an overwhelming majority, and Mr. Richards was loudly cheered on entering the conference hall. On the other hand, Mr. A. J. Cook, secretary of the Miners' Federation of Great Britain, speaking last Sunday at Royston, near Barnsley, stated that the present mining industry agreement was a negation of nationalisation for which the Federation was working. They must work, he added, for the nationalisation of all industries connected with coal, iron and steel. He urged the remodelling of the Miners' Federation and the formation of one union for the whole mining industry.

The latest ascertainment in the coal mining industry for the Eastern Area, which includes Yorkshire, Derbyshire, Notts, Leicester, Warwick, and Cannock Chase, show that the percentage addition on the 1914 basis is 79·83 for July, as against 77·44 for June. This provides an increase in wages per shift which ranges from 1*d*. to 3*d*. varying with the classes of workers.

Representatives of the twelve unions covering the light castings industry in England and Scotland have held several meetings with representatives of the National Light Castings Ironfounders' Federation, with a view to consider the men's claim for an advance of 15*s*. per week in wages, and a proportional advance for youths and lads. The claims formed the subject of lengthy discussions. It is reported that the employers do not see their way to grant any advance in wages. The unions concerned are further considering the matter, which will come up afresh in about a fortnight.

A demonstration was held in Nottingham on Sunday to celebrate the fusion of the National Union of General Workers, the Municipal Employees Association and the National Amalgamated Union of Labour. It was stated that the new body started with a combined membership of 500,000, the branches numbering 1,800, there being 13 members of Parliament directly representing the concern.

The semi-skilled and unskilled men employed at Woolwich Arsenal are dissatisfied with a recent resolution of the War Office. The latter decided that the semi-skilled and unskilled men who did not receive a full 3*s*. per week increase in wages in February last shall receive, as from the first pay-day in May, such an increase as will give them the 3*s*. The men claim that they are entitled to a 6*s*. per week increase, the same as was recently granted by an Arbitration Court to the skilled workers in the arsenal. The men involved are said to number about 7,000.

BROOKHIRST SWITCHGEAR COMPANY, LIMITED.—The Brookhirst Switchgear Company, Limited, Northgate Works, Chester, has just issued three refill cards of their calendar for July, August and September, illustrating three of their switchgear installations.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 834 *of last volume.*)

ON the Wednesday afternoon, June 25, a reception was held at Syon House, Brentford, by the Duke and Duchess of Northumberland, and in the evening the Institution Banquet was held at the Connaught Rooms, Great Queen-street, when the President proposed the toast of "Our Guests from Abroad," which was replied to by M. Doyère, Director of Naval Construction, France; by Mr. J. A. Lambrechtsen, President of the Marine Engineering Section of the Royal Society of Engineers in Holland; and by Rear Admiral A. P. Niblack, of the United States Navy. The toast of the Institution of Naval Architects was proposed by M. le Marquis de Chasseloup-Labaut, the Treasurer of the Institution of Civil Engineers of France, to which the Right Hon. Lord Weir, P.C., LL.D., Vice-President, replied.

Thursday morning was devoted to a visit to the British Empire Exhibition, and the Duke of Devonshire and Sir Travers Clarke returned with the party to lunch at the Great Central Hotel, Marylebone. In the evening a reception was given by His Majesty's Government at Lancaster House.

At the meeting on Friday morning in the Lecture Hall of the Institution of Civil Engineers, the Duke of Northumberland presided and after formal business had been transacted, three papers were read and discussed.

PROGRESS IN MARINE PROPULSION.

The first contribution was submitted by Sir Archibald C. Ross, K.B.E., President of the North-East Coast Institution of Engineers and Shipbuilders, who took as his subject, "The Progress in Marine Propulsion during the last Ten Years and some of its Possibilities." In his opening remarks Sir Archibald referred to the fact that he gave a paper on "The Progress of the Marine Steam Engine on the North-East Coast during the last Fifteen Years," at the last joint meeting of the Institution at Newcastle in 1914. The early review gave them an indication of the conditions during that period, and the new paper was written to provide a further extension of the times dealt with, but owing to the wonderful work done in engineering, especially in regard to internal-combustion engines, it was necessary to change the title. It was doubtful whether sufficient credit and honour could even be paid to the many large and small firms who had spared neither care nor money in striving for further economies on fuel consumption, by applying their efforts to this important subject. Not only should the work done in development be mentioned, but also the adoption of the engines in very large numbers by the mercantile marine at home and abroad. Had it been prophesied in 1914 that a 9,000-ton deadweight vessel would be run at 11 knots on 9½ tons of crude oil fuel for 24 hours, it would have provoked incredibility, but such vessels were in service to-day. It would likewise have been incorrect, though inconceivable, to predict that the rivalry between the four-stroke and the two-stroke engines would have been nearer solution. To-day no single type of engine could be given pre-eminence, but signs were not lacking that the goal aimed at was a double-acting engine, which for space, weight, reliability and economy would eventually become the favourite. Their problem was the extraction of the maximum power from the minimum amount of fuel. Continuing, Sir Archibald said that in a paper on "The Problem of the World's Supply of Energy," read before the Franklin Institute in 1920, Dr. Arrhenius estimated the durability of the supplies of coal and oil. He gave the former as 1,500 years and the latter as only 90 years. Were the 65,000,000 gross tons of available shipping of the world in commission, and all fitted for the use of oil fuel either in burners under boilers or in the cylinders of internal-combustion engines, the amount of oil consumed in a year's running of 200 days, excluding naval requirements, would amount to 45,000,000 tons. The crying need for economy was therefore apparent. After referring to the individual firms who took part in the development of the internal-combustion engine, the author stated that the horse-power of these engines had increased to amounts considered quite impracticable 10 years ago, and the stage was now reached when we could build twin screw vessels fitted with engines of 13,000 and 16,500 brake horse-power and, what was more remarkable, with piston speeds of over 1,200 feet per minute.

The marine steam engine was far from dead. The Admiralty had made great advances in the use of superheated steam and the retaining of superheat at low rates of combustion. While this feature was only applicable to vessels which were required to steam for long periods at powers of about one-tenth of the maximum it was of great interest as marking a distinct development. The people of Great Britain, having great natural resources of coal, should gain in full measure the honour of reducing the loss of energy between the fuel and the propeller. During the European War there was an almost complete absence of engine trouble in the Navy, a phase also familiar to airmen, motorists and even the internal combustion marine engineer. Vessels of great horse-power, completed in haste, were put straight into action or sent to a far destination, and did everything that was expected of them and even more. This great accomplishment was due to the turbine, to gearing and to oil fuel. In mercantile practice some troubles had been experienced with gearing, but as long as coal lasted and steam was used there was a need for gearing. Too much must not be expected from the steel used in making the gear wheels any more than cylinder liners and covers would be expected to withstand very high temperatures. It should not be impossible to improve the designs, to permit greater flexibility on double reduction gearing. Mechanical gearing had the great merit of losing only 2 to 3 per cent. mechanical efficiency. Other methods of reducing the speed of a turbine had received attention and hydraulic transmission, though it did not compete in efficiency with gearing, gave conditions which made for economy in running such as the use of high superheat in turbines revolving in one direction only, the safer adoption of end tightening of blading, the elimination of astern units and a probable reduction in cost of manufacture.

With the practical adoption of higher pressures, superheat water-tube boilers, mechanical stokers, the highest possible vacuum and feed heating, further economies might be looked for, and on the basis of fuel consumption per brake horse-hower would come within measurable distance of the internal combustion engine. It was surely a sign of conservatism that there had not been a more general adoption of the water-tube boiler in the mercantile marine. The arguments against its use were the effects due to salt water, pitting of tubes, unfamiliarity with the method of construction and repair. These must be overcome in time and advantage taken of the great saving in space and weight. Although at the present time a defect on a single condenser tube might necessitate the closing down of an engine, it surely was not beyond the powers of the metallurgist and the engineer to find methods to overcome this. The metallurgists and the manufacturers of materials had done much to make improvement possible in the performance of a marine engine. High temperatures of superheat necessitated the careful choice of materials and reliance must be placed on the metallurgist to produce them.

Mr. Harold E. Yarrow in opening the discussion, said he had had little experience of marine internal combustion engines as they were not suitable for high-speed craft, or other cases where weight was a vital consideration. The competition of internal combustion engines, however, had made necessary such developments in steam practice as would ensure the attainment of the highest efficiency. The use of high-pressure steam, high degrees of superheat, and preheating the air for the boilers would produce distinct improvements. He asked the author for the figures for the comparison of the consumption of fuel oil on steam-driven vessels and those propelled by internal combustion engines. Information was wanted on the possible use of Diesel engines of high powers, associated with reasonable weights, which were necessary in cross-channel ships and Atlantic liners.

Mr. Endert asked the opinion of the author of the paper for his views on the question of oil engines in the future. Engineers waited for a long time before they started to build Diesel engines of large size and in quantity. They had good and suitable plants for the manufacture of steam machinery, but for long were not convinced that putting down large plant for manufacturing Diesel engines would prove profitable. The last few years had witnessed a great change of outlook. Although the engineers on the continent were the pioneers they had now to make every effort to keep abreast of the improvements made in this country. Specialisation was necessary if internal combustion engines were to be made at small cost. On the probable position in the future must be based the decision as to putting down works to concentrate on the manufacture of oil engines.

Professor Goss, of California, referred to the statement made in Sir Archibald's paper that electric propulsion could not be said to have made much headway during the last ten years. He called attention to the fact that all the capital ships of the United States Navy were fitted with electric transmission equipment and said he would submit exact figures in writing regarding tests made on American ferry boats with Diesel electric and turbine-electric drives. The engines used consumed about a half-pound of oil per horse-power hour. The result was not so good as it might be, but what they aimed at was flexibility of running rather than economy simply, and they had had to make a sacrifice. The boats were fitted with pilot-house control. The turbine-electric consumptions were about 1 lb. of oil per shaft horse-power per hour. The United States Shipping Board had shown consumptions for vessels with the electric drive of 1·2 lb. to 1·3 lb. per shaft horse-power hour.

Sir Archibald Denny paid tribute to the late Lord Pirrie, for the part he had played in the development of the marine Diesel engine. Technically and mechanically the internal combustion engine was perfectly successful. There was, however, room for improvement in the reduction of the relationship of weight to power. It was most unlikely that the great inventor of the steam turbine would sit down to opposition. The troubles with geared turbines were mainly due to double reduction gears. The estimated period of years in which the coal supplies would be exhausted seemed to grow continuously as the years went on. He was glad that the author called attention to the necessity for careful design of auxiliaries. Unless every care and attention was given to the many problems connected with them, the result might be a considerable waste of power.

Mr. Summers Hunter thought that the time was opportune for a complete review of marine propulsion progress such as Sir Archibald Ross had given them. They had to give the closest possible attention to questions relating to the provision of materials that would withstand high pressures and temperatures. Such work was done by individual firms in their laboratories, and though it might be better in some respects if the work was carried out by the industry, the important thing was that the information made available should be passed on for the information of all. The growth of the expected life of the coal supplies was undoubtedly due to the extension of their knowledge of the Empire resources. One factor of great importance in connection with the use of new types of machinery was the training of engineers. There were young men available who had had excellent training, and if the firms gave them opportunities it was likely that great economies could be effected.

Mr. Howden Hume suggested that among many ways in which economies could be effected the use of air preheating was not the least. In the preheater invented by Ljungström the flue gases gave their heat to the same metallic surfaces, from which it was taken by the air. Higher steam pressures were a possible sources of effecting economies. There was some aversion to the use of water-tube boilers on ships, but he could give the hint that marine engineers would hear shortly of

a cylindrical boiler design suitable for high pressures.

Mr. Ainsley said that while they all seemed to be in agreement that in gearing flexibility must be striven for, it was possible to provide too much. With too great flexibility vibration took place. In a merchantman the ship itself was flexible, and rigidity was then required in the gear.

Sir Archibald Ross, in reply, said his paper was merely to be regarded as a milestone. It told the story of ten years' development. He was glad that Mr. Endert had testified to the good work done in Britain, the complimentary remarks he made were much appreciated. Holland had contributed so much to the improvement of naval architecture and marine engineering that Mr. Endert's remarks were all the more to be appreciated. He would be glad to have full information on the results attained by electric transmission in ferry boats through the results of tests promised by Prof. Goss. In referring to the electric drive he was dealing solely with the progress made in Europe. A committee was engaged on questions relating to condenser tubes, and it was hoped a solution would be found. He did not want to be misunderstood about double reduction gearing. In the Navy, however, where the gear used was of the single-reduction type, failures were practically unknown. Some of the questions asked, involving figures, were such that a detailed answer would only be possible when dealing with the written discussion.

The President, in proposing a vote of thanks to the author, said that the paper was an interesting summary of the results already obtained in marine propulsion, and gave very valuable suggestions for the future.

The North-Eastern Werkspoor Double-Acting Diesel Engine.

Mr. G. J. Lugt then read the paper contributed jointly by himself and Mr. Harry Hunter, B.Sc., on "A New Type of Double-acting Diesel Engine for Marine Purposes." This paper is reprinted on this and the three succeeding pages.

M. Doyère opened the discussion and stated that unfortunately in France the use of Diesel engines in merchant ships was not extensive. They were, however, much interested in the use of light engines for submarines. The ingenuity shown in getting over the troubles experienced with Diesel engines for ship propulsion was quite remarkable. Weights and fuel consumptions had been greatly reduced. The advantages shown in this way were so great that if it were possible to attain the same results in light types of engines it would cause quite a revolution in submarine construction.

Mr. Lambrechtsen followed and said he believed that the Werkspoor firm were the first to equip a ship with Diesel engines, and congratulated the firm and the North-Eastern Marine Engineering Company on their latest enterprise. He noted how many difficulties such as that of subjecting stuffing boxes to high pressures had been avoided in the design by Mr. Lugt. It was very difficult for the shipowner to decide between the merits of the different engines. The oil engine development was encouraging work on the improvement of the steam engine. They could not encourage shipowners to install Diesel engines when they were entirely in the hands of the powerful oil companies.

Sir Robert Dixon said that the Navy was particularly interested in the progress made with Diesel engines, but the new engine, like all the other marine types, was not of much value to them because of its weight and the space it occupied. He thought that the engine of the future must be of the double-acting, two-cycle type—at any rate, for the Navy—and suggested that the difficulties had been exaggerated. The Germans had produced a double-acting, two-stroke engine. He supposed that the valves for the lower combustion space were operated by long push rods, in which case it would be interesting to hear how expansion allowances were made. The authors emphasised the importance of accessibilty in a marine oil engine, a matter in which he agreed with them. The tendency should be to make the engine as simple as possible.

Sir James Henderson spoke of experiments conducted by Professor Hopkinson fifteen years ago from which the importance of the losses due to radiation was evident.

Mr. Harry Hunter replied to the discussion, and stated in answer to M. Doyère that the engine was expressly designed for use in merchant ships. The variation in the turning moment was not of much importance. In the German engine referred to by Sir Robert Dixon he believed that there were lower pressures in the bottom end. Push rods were used for the valves, and expansion troubles had been overcome with the gear fitted.

The Duke of Northumberland expressed the thanks of the members to the authors for their paper, which described an engine of great ingenuity in the development of which much enterprise had been shown.

An Approximate Formula for the Relationship of Displacement and Draught.

Mr. W. H. Riddlesworth, M.Sc., then presented his paper on "Displacement Draught Formulæ," in which he showed the derivation of an approximate method of arriving quickly at the relationship between displacement and draught when the more accurate formal methods could not be used, even if time permitted, because the necessary complete information was not then available. After first showing that the alteration of block coefficient for a change in draught was equal to the difference between the water-plane area and the displacement coefficients all divided by the draught in feet, the author deduced that the displacement was proportional to the draught raised to a power equal to the coefficient of the water-plane area divided by the coefficient of displacement. When these two coefficients were plotted for a large number of ships each for a wide range of draught, it was found that a straight line represented fairly well the relationship between them. Using the equation to this line and substituting it in the general equation for displacement, an expression was obtained which gave the displacement in terms of the draught and displacement coefficient at any known position. Accepting the simple equation that the coefficient of water-plane area $= \frac{1}{3} + \frac{2}{3}$ of the coefficient of displacement expressed average practice with sufficient accuracy for everyday use, a final expression was obtained for the displacement which took the form of the product of length on load-water line, breadth, draught, and block coefficient divided by 35. A slide rule with circular scales for displacement, draught, and block coefficient was shown which was constructed for use in rapidly dealing with these ship calculations.

Professor Percy Hillhouse said the method of making preliminary calculations described by the author was one of the greatest practical use and was surprisingly reliable. The curious thing was that the method, though simple, could be used for any type of ship and was accurate within a few tons in displacement.

Professor Welch felt chary about accepting approximate formulæ in general, unless the scientific basis on which they were built up was known. In the method proposed they had the guarantee that this had been considered. He had checked some examples by the method and found that they were reasonably accurate. The vital expression was that connecting the coefficients of water plane area and displacement, but there seemed, however, to be no scientific reason why the relationship suggested should exist.

Mr. Riddlesworth, in reply, said that in every case moulded breadth was used. It was mainly because the displacement curve of a ship was not fair that the approximate formula failed to give accurate results but a correcting factor could be introduced.

The Duke of Northumberland, after expressing the indebtedness of the Institution to Mr. Riddlesworth and calling for a vote of thanks, stated that the papers read at the meetings had proved to be as interesting a series as they had ever had submitted to them.

The meeting was then terminated, after a vote of thanks was accorded the Duke of Northumberland, on the motion of Mr. W. H. Whiting, seconded by Professor Welch, for the work he had done for the Institution as President and for the manner in which he had conducted the proceedings.

Lloyds Register of Shipping entertained a party, comprising leading members of the three Institutions and the guests from other countries, at their offices 71, Fenchurch Street, at which Mr. J. Herbert Scrutton, the Chairman of Lloyds, presided. In the afternoon an enjoyable excursion was made by the steamer Golden Eagle on the lower Thames, and in the evening a concert, supper and dance was held at the Hotel Cecil.

Saturday morning was devoted to a visit to the William Froude National Tank at the National Physical Laboratory, Teddington, when the party were received by Sir Joseph Petavel, Director of the Laboratory, and Mr. G. S. Baker, Superintendent of the Tank. In the afternoon the members visited Windsor Castle.

After travelling to Glasgow on Sunday, the party spent Monday on an excursion down the River Clyde on the steamer Duchess of Argyll, and were entertained at Brodick Castle by the Most Hon. the Marquis and Marchioness of Graham. In the evening a banquet was held in the Grosvenor Restaurant, Glasgow. Excursions to the works of Messrs. G. and J. Weir, Limited, and the Fairfield Shipbuilding and Engineering Company, Limited, and to Loch Lomond were made on Tuesday, after which the party entrained for Newcastle-on-Tyne.

On Wednesday visits were paid to many of the great shipbuilding yards on the Tyne, and a banquet was given in the evening by the North-East Coast Institution of Engineers and Shipbuilders in the Grand Assembly Rooms, Newcastle-on-Tyne. This was the conclusion of the summer meetings, and the London members and Continental friends returned to London on Thursday. Great credit must be given to the President and to the Councils of the three Institutions, and in particular to Mr. R. W. Dana, the Secretary of the Institution of Naval Architects, for the excellent arrangements made by them for these memorable meetings.

A NEW TYPE OF DOUBLE-ACTING DIESEL ENGINE FOR MARINE PURPOSES.*

By G. J. Lugt and Harry Hunter, B.Sc.

The success of the Diesel engine for marine work has created a demand for larger powers than can be achieved with the four-cycle single-acting engine, there being a practical limit to the number of cylinders of an engine and to their size. Hence the necessity has arisen of increasing the output per cylinder, to which end three systems are available :—(*a*) Four-cycle double-acting ; (*b*) two-cycle single-acting ; (*c*) Two-cycle double-acting. If the output of a single-acting four-cycle engine is taken as 1, the powers developed by the engines mentioned under (*a*), (*b*) and (*c*) are, roughly speaking : 2, 2, and 4. Leaving out the third solution, (*c*), which, although giving the maximum power for a certain size of cylinder, undoubtedly presents the most difficult constructional problems to solve, a choice must be made between (*a*) and (*b*). Naturally, a builder of four-cycle engines prefers solution (*a*), because it gives him the opportunity of making use of the experience gained. But even a firm without a history in the production of Diesel engines could find several reasons for preferring solution (*a*) to solution (*b*). Enumerating them would mean starting a discussion on the merits of the four- as against the two-cycle systems, a question which would appear to have been discussed almost to a surfeit, and we shall therefore refrain from saying why we have made the four-cycle double-acting engine, and restrict ourselves to describing how we made it.

The difficulties which confront the designer when starting the construction of a double-acting engine are numerous. Putting them as simply as possible, they are principally :—(1) The injection of the fuel in the bottom cylinder ; (2) The position of the valves ; (3) The safeguarding of the piston-rod ; (4) The valve-actuation ; (5) The stuffing-box. Even in a single-acting four-cycle engine it is difficult to find room for all the valves in the cylinder head, and it is clear that on the bottom the difficulty is further increased by the presence of the stuffing-box, which, when one piston-rod is used, is placed where one would like to put the fuel valve. The inlet and exhaust valves must be placed at an angle or in pockets, and in either case

* Paper read at the Joint Summer Meeting of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North East Coast Institution of Engineers and Shipbuilders in London, on Friday, June 27, 1924.

they will very likely be more or less inaccessible, and consequently complicated means of actuating the valve will probably have to be adopted. The piston-rod is in the centre of the combustion chamber, and must be cooled and of suitable material to withstand the heat strains, and it has to be safeguarded from bending as a result of one-sided heating. Every way out of these difficulties seems more or less of a compromise if we try to tackle them one by one, but they all disappear *in corpora* if we do two things: work with a lower compression on the bottom side, and put the compression space not underneath the piston but entirely outside the circumference of the cylinder (see Fig. 1, annexed). This, then, is the simple solution we adopted, and it has proved a panacea for the troubles mentioned. This compression space serves as a combustion-chamber, and is only connected with the cylinder itself by a passage. All the valves are located in the combustion-chamber; the inlet and exhaust valves are placed vertically, are easily dismountable, and can be worked very simply by cams on the existing camshaft. The combustion-chamber can be shaped to the best advantage, perfectly ovoidal, and the fuel injection is placed in the axis of the combustion-chamber. Moreover, the bottom cylinder cover acquires a very simple cylindrical shape, only pierced in one place by the passage leading to the combustion-chamber.

The clearance between the bottom cover and the piston at its botton dead centre must be made a minimum, in order to get as much air as possible in the combustion-chamber. This is, of course, imperative, as the air enclosed in this clearance takes no part in the combustion, which virtually means a reduction of the volumetric efficiency and a necessary reduction of the mean pressure at the bottom. This is, indeed, a loss as far as the power developed is concerned, but it means, on the other hand, a big advantage because of the lower temperatures which exist in the cylinder itself during the process of combustion. It means that the stuffing-box and the piston-rod are well protected against the influence of the combustion, and that the entire bottom cylinder remains much cooler. Allowing that there is a small loss in power, there is a very appreciable gain in reliability. Now full advantage can only be got out of this simple construction if the combustion-chamber is made sufficiently large. This, however, means a low compression, and evidently the compression pressure cannot be reduced arbitrarily, because we must be certain that self-ignition will take place. To obtain self-ignition, however, it is by no means necessary to have a compression of 450–500 lb., as is usual in Diesel engines with air injection. A Diesel engine has to be started from cold, and it has been shown that the end temperature of the compression during the starting period is very much lower than could be expected theoretically. For this reason a high compression is necessary in a cylinder which is used for starting; but high compression is not essential in the bottom side of a double-acting engine, the top side of which is used for starting. Once the engine is running, self-ignition on the bottom side can be obtained with a much lower compression. For various reasons, to be referred to later on, the compression on the bottom side was made so low that self-ignition does not take place without preheating the combustion-chamber. This seems a complication, but the fact that the engine is running, that the top cylinders can be immediately fully loaded, and the exhaust gases leave them with a high temperature—say 700 deg. F. to 800 deg. F.—procures a very simple means of effecting this pre-heating. When the engine is put on fuel (top side only), and during the time the engine is loaded, the exhaust valves of the bottom cylinders are kept open; the inlet valves, however, are put out of action and remain shut. Consequently, hot exhaust gases instead of cold air pass into the bottom cylinder during each upward stroke. In the combustion-chamber is an uncooled liner, which is heated by the exhaust gases for some time before the fuel injection begins. The actual operations take less time than it takes to describe them; with a compression of 250 lb. it takes less than four minutes to preheat the bottom cylinder sufficiently to get smokeless combustion immediately the fuel is put on. The first intention was to keep the compression still lower than that which we are using now, and self-ignition was obtained on the small experimental engine when the compression was only about 125 lb. It was thought at the time that the main difficulties in the double-acting engine would be the stuffing-box and the piston-rod, and the object was to realise a cycle in the bottom cylinder with mean pressures and mean temperatures not surpassing those encountered in the H.P. cylinder of a superheated steam engine, for which the problem of a suitable stuffing-box can be regarded as satisfactorily solved. However, the experiments carried out on the small experimental engine have shown that the stuffing-box does not give any trouble at all, and this encouraged us to adopt in the large engine higher maximum and mean pressures. The trials of the large engine have

Fig. 1.

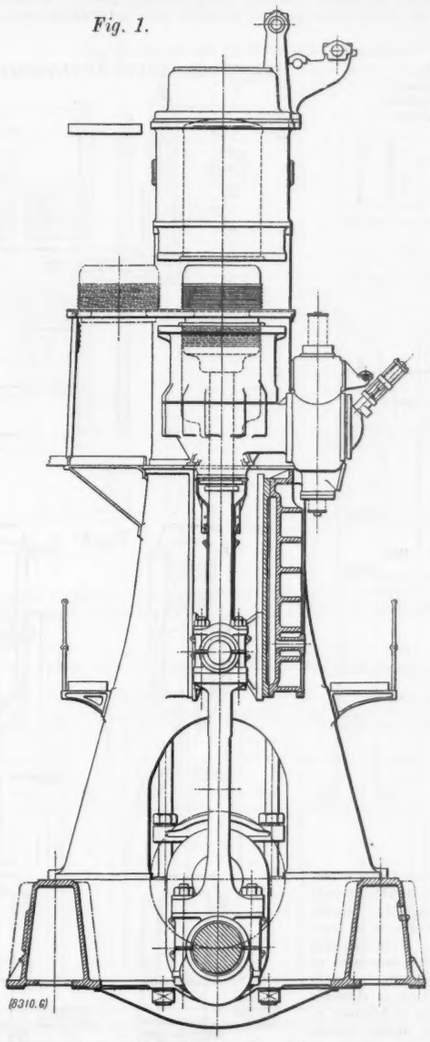


Fig. 2.

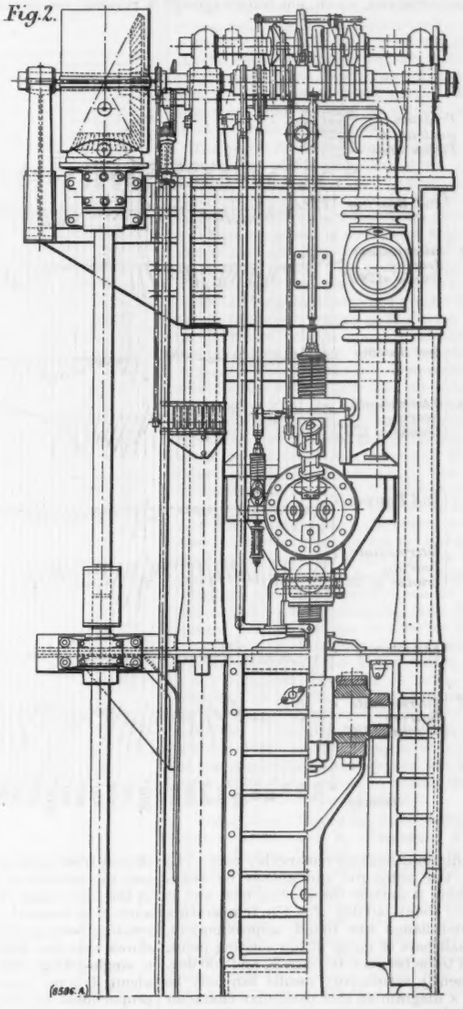
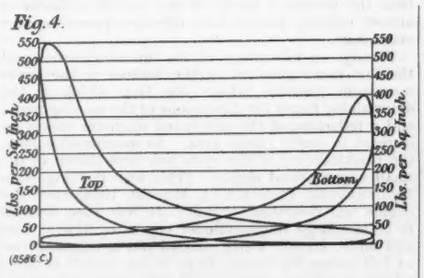


Fig. 4.



fully justified this procedure. The experiments, preliminary to the building of the large unit which is now at work on the test-bed at Wallsend, have served the purpose of ascertaining which form the combustion-chamber should have and what shape of diagram should be aimed at in order to get best efficiency, low temperatures in the cylinder, together with low mechanical strains on the working parts. The diagrams (Fig. 4) bear a great resemblance to a gas-engine diagram; the combustion is at constant volume, which means that it takes place almost entirely during the time the piston is traversing the lower dead centre. Consequently, the flame never enters the cylinder and never touches the piston-rod, which, not being exposed to the direct radiation, remains remarkably cool. The temperature of the piston-rod can always be ascertained by touching it outside the stuffing-box, and it never rises above about 140 deg. F. The temperature of the piston-rod flange was found, approximately, by inserting small bars of metal of low melting-point, which showed it to be between 160 deg. F. and 200 deg. F. These eminently satisfactory results can only be obtained when a diagram of this particular character is realised, showing a low compression and a combustion at constant volume, but without after-burning.

One reason has now been given why the low compression is beneficial in this case, but there are other reasons. In a cylinder of the size of that in the large experimental unit the volume of the compression space on the bottom is about 3 cub. ft. About 0·7 cub. ft. of air can be considered as not taking part in the combustion, consequently only about 77 per cent. of the air charge can be utilised. If, however, the compression was 450 lb. the compression space would hold only about 2 cub. ft., the volume of lost air remaining the same; thus only about 65 per cent. would be available for combustion. Taking a normal mean pressure of 90 lb. at the top, the bottom will give 77 per cent., or 69 lb. with low compression and only 58 lb. with high compression. It is true that the thermal efficiency is somewhat lower than with a high compression, but the difference is not very great; and considering that the overall mechanical efficiency of the double-acting engine is considerably higher than that of the single-acting engine, the total consumption per brake horse-power of the former is lower than that of the latter. The friction losses, taking them as a percentage of the total indicated horse-power, are much lower; the absolute figure of the friction horse-power is only slightly higher than that found on a single-acting engine. As the bearing friction is an important factor in the total friction, it is instructive to compare the bearing pressures of different systems of engines. These pressures have been plotted out in Fig. 5 for two revolutions of a six-cylinder engine, taking into consideration the weight and inertia of the moving parts, and the mean of their absolute magnitude has been calculated in each case. This shows that the total pressures on the eight bearings are (taking the single-acting four-cycle to be 100), (1) Single-acting four-cycle, 100 with four reversals; (2) Double-acting four-cycle, 104·5 with six reversals; (3) Single-acting two-cycle, 126 with no reversals; (4) Double-acting two-cycle, 86 with eight reversals. A reversal means that the pressure on the bearings is shifted from bottom brass to top brass and *vice versa*, and the number of reversals plays, no doubt, a part in the lubrication of the journal, although the importance of a reversal is certainly far greater in a non-rotating bearing such as the crosshead. This diagram shows that the difference of the bearing pressures of a single-acting and a double-acting engine is only about 4·5 per cent., and as the friction is directly proportional to the pressure the same difference in friction losses can be expected. This, again, means that the indicated power of the bottom cylinder is almost entirely turned into effective power on the crankshaft.

Finally, an advantage of the low compression and the low mean pressure in the bottom is the lower maximum pressure (about 400 lb.), which is the determining factor for dimensions of the moving parts, and a reduction of the piston-rod diameter means an increase in useful piston area. As mentioned earlier, the practicability of the cycle was first shown in the small experimental engine. [This was our Fig. 4 in ENGINEERING, Plate LXXI, May 30, 1924, when the engine was described.—Ed.E.] It was then decided to build a large single-cylinder engine of 31½-in. bore and 55-in. stroke, which carried out a non-stop run at full power for twenty days in the month of May. Of this single-cylinder engine a section and a front elevation are shown in Figs. 1 and 2. [A general view of this engine was reproduced in ENGINEERING on Plate LXX, May 30, 1924.—Ed.E.] The top part of the engine differs but little from the Werkspoor type of single-acting four-cycle engine. The bottom part, which takes the place of the cylinder extension peculiar to that type of engine, consists of a cooled cylinder and a cylindrical cover with stuffing-box. Between the liners of the top and bottom cylinder a small distance is left, enough to give the liners freedom to extend downwards and upwards. This heat extension was found to be only a fraction of a millimetre, and there is no objection whatever to running the piston-rings over the gap, which practically closes when the engine gets hot—no more objection than there is to having a groove for the lubricating oil cut in the cylinder liner. Many years' experience with a liner in two parts with the rings passing over a small gap, has proved it to be an entirely satisfactory practice. With reference to the experimental engine, it must be remarked that the reversing system is only made for the top cylinder. In general, it will be sufficient to have the top alone working when running astern; it is, however, quite possible to make both sides of the cylinder reversible, using the Werkspoor system of reversing with the valve levers mounted on eccentrics which are keyed on the reversing shaft at an angle. This system has been described several times in the engineering papers to which reference can be made.

The combustion-chamber is bolted on to the camshaft side of the bottom cover. Inside is an uncooled liner, the interior of which is shaped to the best advantage for the combustion. This liner extends through the throat and ends about flush with the bottom cylinder cover. In Fig. 1 the combustion chamber is shown, in which the top valve is the exhaust

Fig. 5.

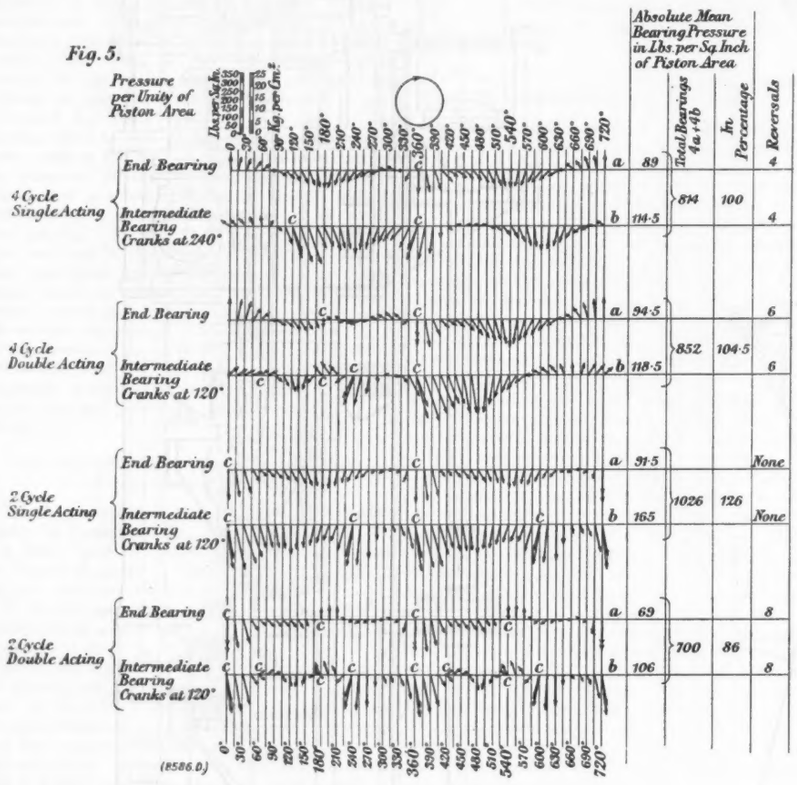


Fig. 7. TEST VALVE ARRANGEMENT.

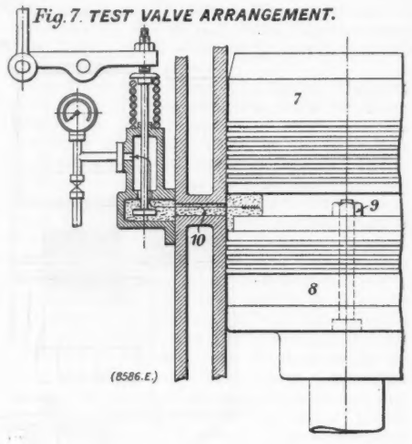
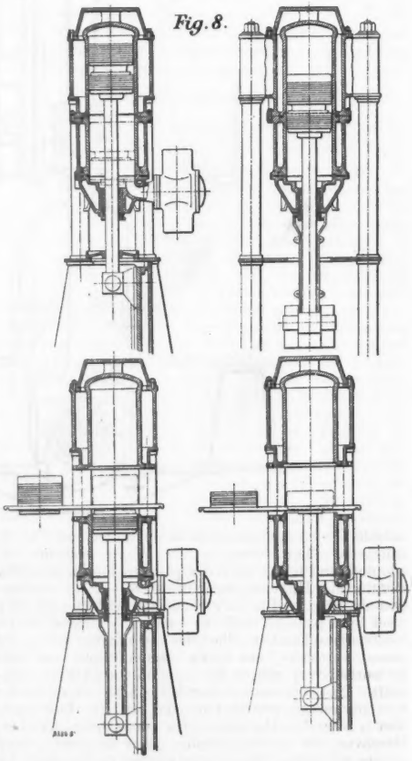


Fig. 8.



one, the bottom one controls the inlet and the side one is the fuel valve. In Fig. 2 the common exhaust pipe is shown connecting the top and bottom ends. A starting valve is only necessary on 3- and 4-cylinder engines. The accessibility and straightforwardness of the construction can be appreciated from these drawings of the engine.

Some misgivings existed before we started the experiments on the influence on the combustion of the throat between the combustion-chamber and cylinder. It was found, however, that no appreciable difference in mean pressure could be detected in indicator cards taken on the former and on the latter. Only when the throat was reduced in area to about half its size by introducing thicker liners could any difference be noticed. Also, the weak spring diagrams show that the loss caused by the throat is very small. One of the objections usually made against double-acting engines is the impossibility of watching the piston, as the cylinder is closed on both sides. In a four-cycle single-acting engine one can see immediately when the piston rings get gummed up, because the piston starts to leak, which can be heard and seen. One can then take measures against it, and if necessary shift the rings at the first opportunity. In a double-acting engine, however, a leak can neither be seen nor heard. A very simple means of detecting a leak of the piston has been adopted which is so sensitive that even the tendency to leak can be detected, and at the same time the condition of the cylinder lubricating oil can be ascertained by this means. The piston consists of two parts, see Fig. 7, which are fixed by bolts on the piston-rod flange. In both parts a number of piston-rings are placed, leaving an open part in the middle between the upper and the lower group of rings. If the rings are leaking (in general this can only be expected from the top rings) the pressure in this open part rises. In the cylinder liner is a small opening connected to a valve, which is opened up by a cam on the camshaft every time the piston passes it after a combustion on the top. From the valve a pipe leads to a gauge, which indicates the pressure. This pressure should be constant, and a rise surely indicates that something is wrong with the rings. A cock in this pipe allows samples of the lubricating oil to be obtained. This device has shown its usefulness during the non-stop run; seeing the gauge at its normal pressure assures the attending engineer that everything inside the cylinder is all right. Still, an occasional examination of the piston-rings is necessary, and it is therefore important to make the piston easily accessible without necessitating the dismantling of numerous and heavy parts. Especially in a double-acting engine, one should be able to inspect the piston without having either to remove the piston from the piston-rod or to disconnect the rod from the crosshead.

The method of opening up the cylinder and dismounting the piston is diagrammatically illustrated in Fig. 8, and the procedure is as follows:—(1) Cast-iron plate (in two halves) on crank-case top plate removed. (2) A tube (in two halves) is placed round the piston-rod, its lower end resting on the crosshead. (3) The engine is then turned till the top end of this tube butts up against the bottom cover. (4) The bolts connecting the top and bottom portions of the cylinder are removed. (5) The engine is turned down, the bottom portion of cylinder coming down with it until the bottom cover rests on the crank case top plate. (6) The top part of the piston is now exactly in the opening between the two portions of the cylinder; for examining the lower rings the tube is removed and the engine two portions of the cylinder; for examining the lower rings the tube is removed and the engine turned up until the bottom part of the piston is in the opening. The cooling of the piston is effected by water, the cooling water being led to and from the piston through telescopic pipes, which are anchored to the astern shoes, a heavy gauge pipe connecting them to the hollow piston-rod. The glands are arranged in a very accessible position above the crank case top plate; a leakage can be easily observed, and no water can reach the crank-case. The glands are of the floating type; even if the telescopic pipes should be seriously out of alignment there can be no strains on them, causing them to break at their base.

The power developed by this type of engine is about 80 per cent. more than that given by a single-acting engine of the same size. Taking into consideration that the piston speed can be made 15 per cent. or 20 per cent. more than that usual in two-cycle engines, and that no power is needed for scavenging purposes, this engine actually develops about the same power as a single-acting two-cycle engine of equal size, with less heat stress on covers and liners. The lubricating oil consumption is not greater than for a single-acting four-cycle engine of the same bore, and power for power it will be roughly one-half. The experimental engine is fitted with air injection both top and bottom. Although the low compression at the bottom would allow a lower injection-air pressure to be used, it was preferred for simplicity's sake to work both top and bottom with the same pressure. It may be remarked here that the size of the air compressor only needs to be very little increased for furnishing the injection air for the bottom. The size of the air compressor of a marine Diesel engine is in the first instance determined by the needs for slow running. A double-acting engine, however, will when running slowly, only be made to fire on the top. This means that no injection air is used on the bottom, and the engine has practically become a single-acting engine. Thus the size of compressor can be determined as if the engine were single-acting, and the excess air at normal revolutions can be used for the bottom. The compressor is therefore always working at about normal capacity, and under better conditions than when throttled down, as is usual in single-acting engines. It may be added that we have also arranged for the use of solid injection in both top and bottom cylinders. In particular, the bottom cylinder presents perfect conditions for using solid injection, the shape of the combustion-chamber and the shape of the diagram which it is desired to obtain lending themselves eminently well for its adoption.

The system of solid injection which we are using is that put forward by Professor Arschaouloff, and although not directly connected to the subject—it being very little known in England—we should like to give a brief description of it. The high pressure fuel pump (Fig 9) is driven by a small impulse piston below, the impulse cylinder being in open communication with the main working cylinder. The ratio between the areas of the impulse piston and the fuel pump plunger determines the pressure of the fuel in the pump. If the compression is 370 lb. and this ratio 1 : 13, the fuel pressure would be 4,800 lb. A spring-loaded spindle valve of the differential type is opened automatically when the compression in the fuel pump has risen to a certain figure, and the fuel enters the cylinder. The pressure rises when the injected fuel burns, and causes new fuel to enter with increased pressure. The diagram shown in Fig. 9 has been made on the small experimental engine. This diagram shows a normal card, a displaced card, and a card taken simultaneously of the travel of the impulse piston. This impulse piston starts to come down at the point (*a*) when the differential valve is opened. The rise in pressure in the cylinder does not take place immediately; on the contrary, a drop in pressure can be noticed, partly due to the compression space being increased in volume because of the impulse piston coming down, and partly to the cooling effect of the entering fuel being vaporized. At point (*b*) the fuel suddenly flashes off. The time-lag can be determined on the crank circle, and the figures found fit in exactly with the experimental results published by Commander Hawkes in his paper on "Some Experiments in Connection with the Injection and Combustion of Fuel-oil in Diesel Engines," read before the North-East Coast Institution of Engineers and Shipbuilders. In point (*c*) all the fuel has been injected into the cylinder and the spindle valve closes. This diagram gives a remarkable insight into the process of combustion. The amount of fuel injected can be

Fig. 9. SOLID INJECTION, ARSCHAOULOFF SYSTEM.

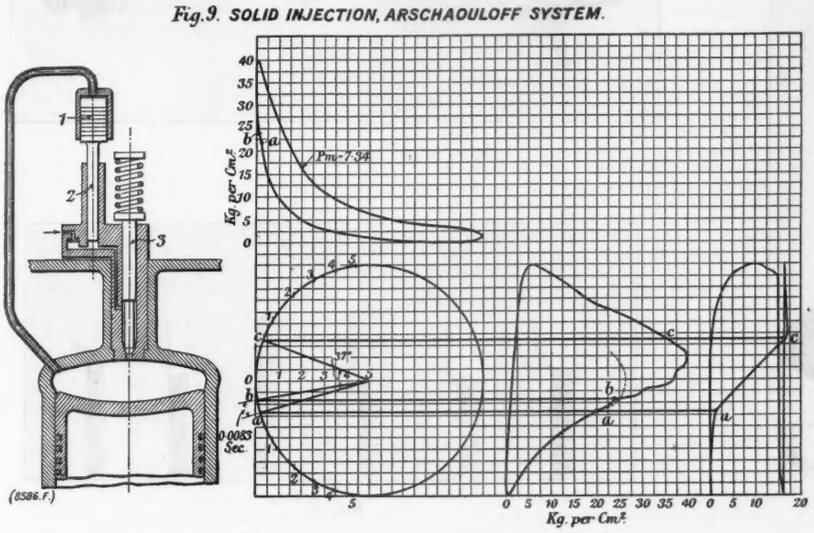
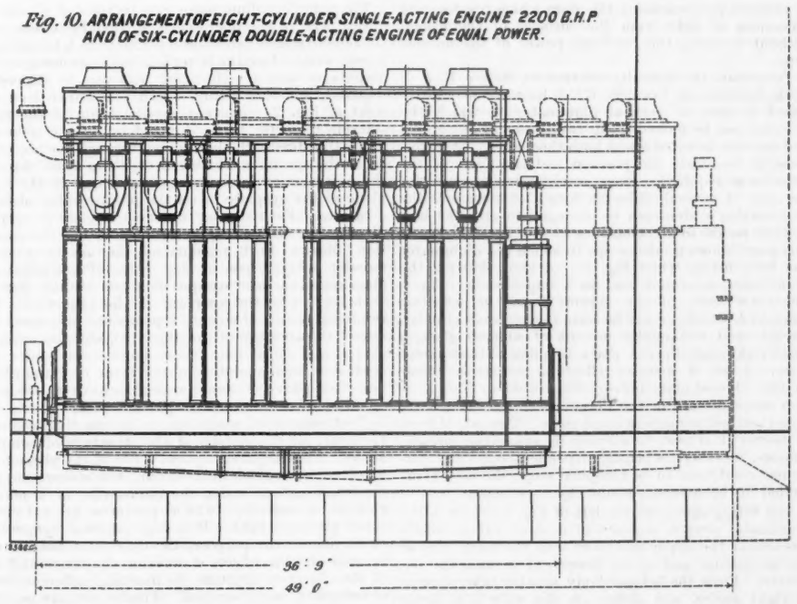


Fig. 10. ARRANGEMENT OF EIGHT-CYLINDER SINGLE-ACTING ENGINE 2200 B.H.P. AND OF SIX-CYLINDER DOUBLE-ACTING ENGINE OF EQUAL POWER.



VERTICAL ILLUMINATOR FOR MICROSCOPES.

CONSTRUCTED BY MESSRS. R. AND J. BECK, LIMITED, LONDON.

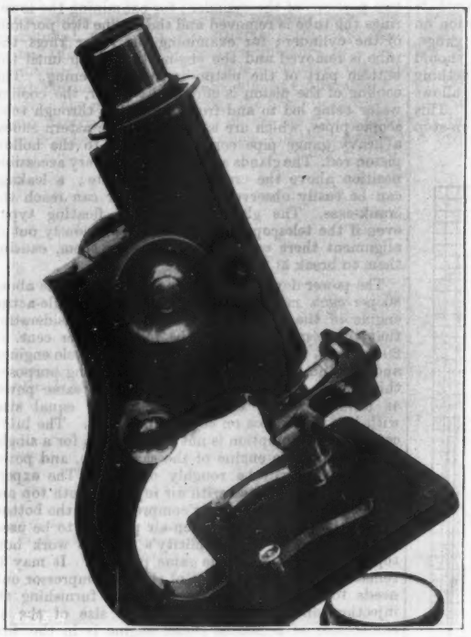


FIG. 1.

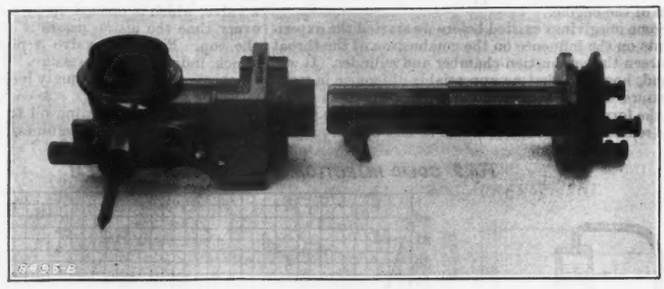


FIG. 2.

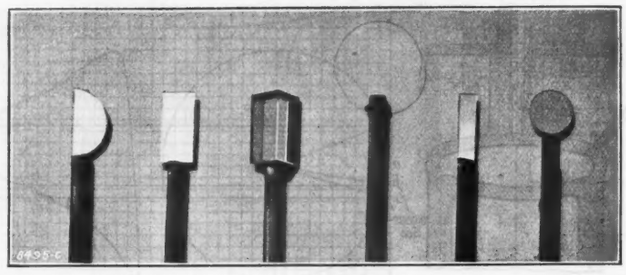


FIG. 3.

easily computed at any moment, and the corresponding rise of pressure seen on the diagram. It is interesting to note that about 42 per cent. of the fuel is introduced before the dead centre.

In conclusion, Fig. 10 shows the advantages to be gained by the installation of a double-acting engine instead of a single-acting engine. This is not a hypothetical case, but it compares an eight-cylinder engine actually being built with what would now be proposed for a sister ship. The proposed six-cylinder double-acting engine is about 20 per cent. lighter; the engine-room would be 12 ft. shorter; the fuel consumption will be lower, and the lubricating oil consumption considerably less. In the case of a twin-screw vessel fitted with single acting engines, their substitution by a single-screw double-acting engine shows a very marked simplification in every direction. We quite realize that from a theoretical point of view the solution can be considered doubtful, if not wrong. It seems, indeed, going the wrong way deliberately to abandon part of the air present in the cylinder and not to use it in burning fuel, to accept a low compression when obviously the thermal efficiency is better with a high compression. This, however, is the academic side of the question, but the practical side is that we want to have a reliable, simple, and accessible engine, even if we have to deny ourselves the satisfaction of getting the highest possible mean pressure and the lowest attainable fuel consumption per indicated horse-power. We think this is a point which every engineer with sea experience will appreciate, and the shipowner should not worry much about thermal efficiency if he can keep the repair bills down and if the ship has no undue delays.

VERTICAL ILLUMINATOR FOR MICROSCOPES.

WHEN using a high-powered objective for the visual examination under the microscope, or the photomicrography, of opaque bodies, such as the specimens used in metallographical work, it is necessary to illuminate the object on the stage by means of a beam of light passed downwards through the lens of the microscope. For this purpose it is usual to employ a fitting inserted between the tube of the microscope and the objective, and containing either a thin disc of plane glass or a small right-angled prism to reflect a horizontal beam of light, admitted through an opening in the side of the fitting, vertically downwards through the objective. The only adjustment provided is to enable the reflecting glass or prism to be partially rotated about a horizontal axis, and, owing to this limitation, considerable difficulty is experienced in practice in eliminating the glare which results from reflections of light from the surfaces of the lenses, without reducing the resolving power of the microscope.

To obviate the difficulty referred to, Messrs. R. & J. Beck, Limited, 68, Cornhill, E.C.3, have recently introduced a form of vertical illuminator in which the reflector can be moved along two lines at right angles and can also be tilted about both these axes. It is thus possible to adjust the position and the angle of the reflector as required. Since provision is also made for the use of several different forms of reflector, the illuminating system can be arranged to give the best possible results in all conditions of working. Fig. 1, on this page, shows a microscope to which the illuminator has been fitted, while Fig. 2 is a view showing the illuminator separately and to a larger scale. Fig. 3 illustrates some of the various forms of reflectors employed, which, as will be seen, include semi-circular, circular and rectangular mirrors of silvered glass, a small right-angled prism, and a thin disc of transparent glass. A set of concave reflectors, similar in outline to the silvered-glass mirrors illustrated in Fig. 3, is also made for use in the illuminator, and these have important advantages in some cases. The actual form of mirror it is best to employ in any given circumstances, however, is largely dependent upon the particular conditions to be complied with, the user being guided in the selection mainly by experience.

The fitting shown on the left of Fig. 2, which is the illuminator proper, consists of a short tubular body screwed at the upper end to fit into the main tube of the microscope and at the lower end to take the objective. From the tubular body, another tube projects at right angles, and sliding on this tube is a sleeve carrying a bracket, which can be rotated about the axis of the tube. Pivoted to the bracket is a boss with a square hole formed in its axis, and in this hole are placed the square rods on which the reflectors are mounted, the rods being passed through holes in the sides of the tubular body, as will be understood on reference to Fig. 2. The rods of the reflectors are clamped in the boss by means of a milled-headed screw, which enables the position of the reflector to be adjusted in the direction of the length of the rod. The boss, and consequently the reflector, can also be tilted about the axis of the rod by means of a lever provided with a knob and clearly shown in both Figs. 1 and 2. The lever can be clamped by a screw working in a segmental slot, and its angular position is indicated by a scale engraved on the bracket. The two other adjustments of the position of the reflector are obtained by sliding the bracket along the projecting tube or rotating it about the axis of the latter.

The complete illuminator can be rotated about the optical axis of the microscope, so that light from any convenient source can be directed into the laterally projecting tube. Into the latter a fitting containing an iris diaphragm and a collimating lens can be slipped if required, and this fitting, which is illustrated on the right of Fig. 2, enables a parallel beam of the most suitable diameter to be directed on to the reflector. The latter directs the light down through the objective on to the specimen which reflects it up again through the objective to form a magnified image in the focal plane of the eyepiece or on the photographic plate in a camera. For reducing the effect of glare in vertical illuminators without appreciably affecting the resolution, Messrs. Beck recommend the use of a small circular opaque spot in the centre of a transparent glass reflector, or of opaque reflectors suitably located with respect to the aperture of the objective. The resolving power, of course, depends not only upon the size of the aperture of the objective, but also upon its shape, and since both these factors are under the control of the operator in the form of illuminator, described above, it would appear to have considerable advantages for metallographical work, where the highest degree of resolution is frequently necessary to bring out the details of the structure of complex alloys. For the purely optical study of the phenomena involved in critical illumination, the makers suggest the examination under the microscope of a minute globule of mercury, which produces an extremely small point of light. If a high-powered eyepiece is employed for the purpose, the diffraction pattern can be seen and the effects of altering the shape and size of the objective aperture, by inserting different forms of reflectors, can be studied. Finally, we may mention that the illuminator described can be used on any form or make of microscope.

SYNTHETIC IRON STUDIES.—A co-operative agreement has been arranged between the British Columbia Bureau of Mines and the Department of the Interior whereby the North-west Experiment Station of the United States Bureau of Mines at Seattle, Washington, will assist the first-named organisation in establishing the best conditions for converting steel scrap, tin-plate scrap, and sponge-iron concentrates into foundry iron and steel, through the medium of the electric furnace. The expense of this investigation will be borne by the British Columbia Bureau of Mines. This work is a continuation of the laboratory work on synthetic iron previously done at Seattle by the Bureau of Mines. It is expected that the results will be applicable to the production of grey iron from sponge iron. The electric furnace to be used in the tests is of the Greene (Heroult) type three-phase, acid-lined, and of 3,000-lb. capacity.

WORLD POWER CONFERENCE.

WE give below abstracts of most of the papers read on Tuesday last. The proceedings at the meetings and the discussions we deal with elsewhere in this issue.

SECTION A—POWER RESOURCES.

World Resources of Coal.—A paper by Sir Richard Redmayne accepts the figure of 7,397,552 million metric tons as the probable coal reserves of the world. Coal mining has been carried on at a depth of 4,000 ft. in Belgium, but it was probable that coal could not be produced economically from a greater depth than 5,000 ft., though much of the reserve included in the figure given is at a greater depth than this. On the present basis of production the resources of the United States might last for 2,000 years. The coal reserves for Great Britain would probably suffice only for 600 years or 450, if coal below 4,000 ft. were excluded. Germany, before the Silesian fields were ceded, had reserves for 1,000 years. Belgium has probably 500 years supply. France would soon have to live entirely on imported coal, and Switzerland would exhaust her supplies in a few years.

As regards anthracite, Asia is easily first in available resources, the province of Shansi containing 75 per cent. of the anthracite of that continent. Of the world's resources over half are of bituminous coal. Seven-eighths of the American supplies are bituminous coal. The principal resources of lignite were in Germany, Canada and Australia. The Latrobe valley, Victoria, contains 31,144,319,000 tons of lignite. If electrical transmission of power were adopted a saving of many million tons of coal could be effected in this country. Oil would not help the situation, the supplies would be exhausted in from 80 to 100 years. Peat supplies would probably be exhausted before coal. It is estimated that water power could be utilised to supply 60 per cent. of the power now generated with coal.

BRITISH EMPIRE AND UNITED STATES RESOURCES.

Great Britain.—The Physical and Chemical Survey of the National Coal Resources of Great Britain was dealt with by Dr. C. H. Lander in three sections. The first considered the distribution of coal and its relation to other rocks and minerals; the second the physical and chemical characteristics of different seams; and the third the purpose for which different classes of coal were best suited. The author first reviewed the work done in different investigations of coal supplies of the country, subsequently summarising the recent work on the origin and characteristics of coal, of Dr. Stopes, Mr. C. A. Seyler and the Lomax Palæobotanical Laboratories. The institution in 1922 of the Lancashire and Cheshire Coalfield Research Committee had been followed by the establishment of one for the Yorkshire coalfield. The work embarked upon in connection with the general survey had already yielded important results.

Professor A. H. Gibson, dealing with water power in Great Britain and Ireland, stated that the State had no ownership of water rights in these countries. Development of resources had been hindered by the multiplicity of the interests and parties affected. The most promising areas were in Scotland, Ireland and North Wales. Of the whole water resources of this country Professor Gibson considered 74 per cent. should be allotted to the needs of general industry; 14 per cent. for electro-chemical industries; 9 per cent. for public services, and 3 per cent. for agriculture. Some 20 per cent. of the power requirements of Great Britain and Ireland could be supplied from water sources.

A paper contributed by Sir G. Beilby, was on the subject of "Oil Production and its Relation to the Resources and Needs of the British Empire." Here the author laid stress upon the fact that the United States were likely to continue to be the centre of the world's production of oil, 70 to 80 per cent. of the total production being controlled by that country. In the mercantile marine less than 69 per cent. of the gross tonnage was now dependent upon coal. All oil resources should be conserved to the utmost extent possible. Great importance attached to the use of the best installations for distilling and refining shale oils. After having decided to what extent a vein of shale was workable, only the best type of plant to suit the particular shale should be adopted. Whereas the production of petrol was to some extent a speculation, and attracted energy and capital for this reason, shale oil production only promised hard work and a slow return for effort. In this country the future source of heavy oils would be coal treated by low-temperature processes. The latter had received attention from the H.M. Fuel Research Station since its organisation in 1917, as being a matter of prime importance.

A matter cognate to the general subject was discussed in a paper by Prof. H. Louis under the title "Resources of the British Empire in Metals employed in Power Machinery." This paper reviewed the export machinery business of Great Britain which was lacking in raw materials, while other countries with raw mineral resources were largely importers. The author then went into the question of the resources of the Empire as regards iron ore, copper, lead, zinc, tin, nickel, cobalt, tungsten, chromium and aluminium, and concluded, that, with the solitary exception of copper, the Empire could look forward to the future with confidence, owing to the existence of ample supplies within its own limits.

Canada.—A most comprehensive and elaborate contribution was a large and profusely-illustrated volume on over 350 pages dealing with the power resources of Canada. Only part of this, however, was concerned with Section A, with which we are now dealing. A first section was devoted to a review of the national resources of water power with which Canada is liberally endowed, contributed by Mr. J. B. Challies. This is available on an abundant scale in the Central Provinces, while other provinces have almost limitless resources of coal of a useful nature. Water power development has been steady and rapid. Over 3¼ million h.p. have been developed with a further ¾ million of plant being installed. In ten years it is estimated that the capital invested will reach 1,000 million dollars. Government co-operation was constructive and positive. No less than 97·7 per cent. of the energy produced by central stations was from hydraulic power. For the paper pulp, the mining and other industries hydraulic power was of prime importance. Water power was well distributed, except for certain parts of the Prairie Provinces. Recent investigations had shown that more than 40,000,000-h.p. were available at the minimum flow. The rights of most of the undeveloped resources belonged to the State, while most of those developed are under State regulation and control. The sources of power belonging to the State are administered by the Government of Canada, which is the administrative authority for all water resources on public lands, as in the provinces of Alberta, Saskatchewan, Manitoba, and Yukon. The legislative assemblies of British Columbia, Quebec, Ontario, &c., control the resources within these territories. The whole subject receives a great amount of attention in the country.

A second section of the Canadian report was by Mr. F. Haanel, who dealt mainly with fuel resources. This should prove a most interesting review to many engineers who on account of the publicity given to water power in the Dominion are apt to overlook the fact that the country has vast resources in the way of coal, lignites, peat and oil shales. The paper discusses at considerable length such practical points as the preparation of these fuels for industrial and other uses, their value for steam raising, gas retort and producer gas work, giving the characteristics of modern installations designed for their use. A part of the report is further devoted to the research side as regards the development of the best methods of carburisation of the different fuels, and the scope of the different processes. Mr. Haanel concludes that Canada has enormous reserves of fuel of all kinds except crude oil. The requirements for steam raising and steam power are increasing. While hydro-electric power has to a large extent displaced steam in Ontario and Quebec, an increasing demand in Central Canada must from now on be met by steam-generated power. Power-plant designs are modern and provided with combustion apparatus for burning the different grades of coal to the best advantage. Powdered fuel systems are being largely adopted. The field did not at present exist for carbonising and briquetting lignite coals. The domestic fuel problem in the "Acute Fuel Region" would best be met with the by-product recovery coke oven. The solution of both the domestic and industrial power problem in Central and Southern Ontario would be found in the large-scale use of the by-product recovery coke oven, to produce motor spirit, oils, ammonia and to generate gas. The first attempt to carbonise coal at low temperature for the production first of a suitable char for use as powdered fuel for steam generation, and secondly, of the maximum recovery of by-products, is being made at the Ford Motor Works, Walkerville, Ontario. At present Western Canada produced more coal than she could use, so that lignites were not likely to be developed for some time. Canada might be regarded as the world's storehouse for future supplies of coal, and possibly also of oils derived from coal.

India.—The power situation for India was reviewed by Mr. J. W. Meares, who drew attention to the importance in tropical countries of impounding available supplies. As India was an agricultural country, the demand for water for that industry was in conflict with that for power production. There were, however, drops on the canals and impounding reservoirs which could be developed without prejudice to irrigation. It was difficult to co-ordinate the rights of the various Presidencies, States and Provinces. India has large possible sources of power which could be developed if some use for the supply could be assured. At present this power was not within reach of any existing industries except agriculture, which wanted water rather than water power.

Australasia.—The report for Australasia was compiled by the Institution of Engineers, Australia, and contains a vast amount of statistical and descriptive material, evidently most carefully got together and selected. The contribution was divided into two parts, the first dealing with resources and the second with existing power supplies. The first part is sub-divided into water, coal and liquid fuels. The country possesses ample reserves of coal, the exact amount of which it is as yet difficult to estimate, while supplies of brown coal are enormous. Over 10 millions horse-power are available on the rivers on the continent, and additional power in Papua and the Mandated territory of New Guinea. It would appear that with such reserves a long while must elapse before Australia is at all inconvenienced in her industrial development. The possibility of discovering oils in economic quantity is also reported upon favourably by geologists. Handicapped by distance it has been impossible at this conference for Australia to present more than a general review of the situation. With a better knowledge of the nature of the congress it will be possible on future occasions to go into greater details. Although the investigations are not complete, many of the States have accumulated a great deal of valuable information, and preliminary measures are now under consideration by the Federal and States Governments with regard to the regulation of national resources.

New Zealand.—New Zealand is largely a country of mountains, with a considerable rainfall. The available water resources, counting only possible installations of 1,000 h.p. and over, amounts to about 770,000 h.p. in the North Island and 4,100,000 h.p. in the South Island. The development of this power was, Mr. Lawrence Birks says in his report, in private hands, but in 1903 a law was passed reserving to the State the rights of development of all water power. Allowing ½ h.p. per head the requirements for the North Island have been estimated at about 160,000 h.p., and for the South at 110,000 h.p. In the North Island there will ultimately be three interconnected stations with 110,000 volt transmission lines of a total length of 1,112 miles and 309 miles of main branch lines. The cost of the complete scheme was estimated in 1918 at 7,303,042*l.* For the South Island the final choice of a comprehensive scheme has not yet been made. Including large and small stations there were in 1923, 31 hydro-electric plants in New Zealand, with a total output of 29,386 kw., representing about 51·1 per cent. of the power used in the Dominion.

South Africa.—Three reports were submitted with regard to South Africa. One was of a comprehensive nature, while the other two dealt respectively with the coal and water resources of Southern Rhodesia. Mr. C. L. Robertson's report on the last-named subject referred to an area about 154,000 sq. miles, traversed by a narrow central plateau of 4,000 ft. to 5,000 ft. This area is divided into six basins. Suitable impounding sites are rare, and the cost of reservoirs is estimated to work out at about 200*l.* per million cub. ft. impounded. In development work, therefore, it is anticipated that large storage schemes would not be included. The author puts the total average horse-power available, excluding the Zambesi, at 135,200 h.p., or including that river at 435,200 h.p. The resources generally are as yet intact, the only large installation being at present that for the Rezende Mine at Pauhalonga.

Mr. H. B. Maufe dealt with the fuel resources of Southern Rhodesia, which comprise coal, wood and charcoal. Neither lignite, peat, oil nor gas has been found in the area. The reserves of coal are conservatively estimated at 6,184 million tons, of which more than 80 per cent. is in the Wankie basin. This coal burns with a short flame and is among the best found in Africa, producing also a good coke for metallurgical purposes. The resources are amply sufficient for all possible developments within sight.

The United States.—The reports for the United States were incomplete, excepting that dealing with the Pacific Coast, but in our report of the proceedings in an earlier part of this issue we deal with all the important papers. Messrs. A. H. Markwart and H. A. Barre stated that the resources of the three Pacific States amount to 43 per cent. of the total for the whole country, totalling about an average of 16 million h.p. Less than 10 per cent. is now developed. California ranks first in the whole country as regards hydro-electric possibilities. The first Pacific installation was on the Willamette River, in Oregon, in 1889. The Pacific Gas and Electric Company owns the most important system in the west, with 3,492 miles of transmission line and a capacity of 474,550 kw., with 31,1615 customers, and covering a territory of 54,000 sq. miles. The Southern California Edison Company occupies second place, with a total installed capacity still greater, viz., 497,800 kw. Interconnection between

the systems of the Pacific Coast has been an accomplished fact for several years, thus reducing the need for steam auxiliary plant. When all the systems are linked up the total will represent 1,867,485 kw. For the moment, the exchange of power between States is not of importance, but this would be augmented when the Colorado river projects materialised in the development of 3,500,000 h.p. International exchange with Mexico and Canada as yet was unimportant. Of the 4,400,000 h.p. of the California-Oregon interconnected system 36 per cent. was used for heating, lighting and cooking, 25 per cent. for industrial purposes, 15 per cent for agriculture, 8 per cent. for railways and 16 per cent. for other uses. The systems have monopolies of territory under state regulation.

EUROPEAN AND OTHER COUNTRIES.

Belgium.—Water power in Belgium is of small importance. The report for this country, by M. A. Fontaine, pointed out that the country possessed no mountains, had a flat and sandy coast line, unsuited to the development of tidal power, and of the moderate rainfall about one-half only ran off into the rivers. There are possibilities of a minor character on the Meuse if a dam were built at Lixhe, where a fall of 9·5 m. could be secured. Other developments could be made above Liege to produce in all about 180 million kw.-hr. With the co-operation of Holland, further works might be built between Lixhe and Maasbracht, while the Lixhe-Antwerp canal could also be utilised to some extent.

Holland.—Professor F. K. van Iterson's report on Holland is in many senses pessimistic, but optimistic in others. The author points out that Dutch engineers have for centuries given a great deal of thought to the use of wind power and of peat fuel, and more recently of tidal energy, but their experience in these directions should act as a warning to enthusiasts elsewhere, if they have any regard for their money. The eight hour day gave the final blow to the employment of windmills, and even the introduction of modern mills of the American type has not saved the situation. Holland has no water power as it is a flat country. The generation of electricity by the burning of peat was never profitable. The drying season was short and all artificial processes had failed. It does not pay to transport this fuel and as an industrial fuel it was useless. If anyone sank money in the winning of peat on a large scale only his grandchildren would benefit when they came into the possession of valuable land. Lignite deposits again in Holland were close to coal, and the latter was naturally worked by preference. The output of coal in Holland is expected ultimately to reach 10 million tons per annum, but with the fields of England, Belgium and Germany close at hand there is no anxiety in the country as to the future.

France.—The French report on Water-power was extremely brief. It was compiled by M. de la Brosse, Inspecteur-Général des Ponts et Chaussées. For many years stream-gauging has been practised and search made for suitable sites for reservoirs. The gauging of flows had been carried out with water-wheels, floats, Pitot tubes, weirs, &c. Two hydraulic laboratories are maintained, one at Grenoble and one at Toulouse, for the rating of gauges. Complete investigations had been made with regard to barrages and reservoirs on the Rhone (Génissat), the Durance (Serre-Ponçon), the Verdon, the Romanche, the Creuse, the Dordogne, &c. Some such works are now in hand, as, for instance, the dam at Eguzon, on the Creuse, and that at La Celette on the Chavanon. The former dam will be 61·11 m. in height, and the latter 87 m. The most important future developments are expected on the Rhine, the Rhone, Isère, Durance, and Dordogue.

Switzerland.—As is well known, Switzerland is greatly favoured from the point of view of water power, and already has developed these resources to such an extent that in 1922 the possible production was placed at 4,870,000,000 kw.-hour. The actual production was 2,880,000,000 kw.-hours, or 59 per cent. of the total possible. The report on Switzerland was a composite production by Messrs. Buchi, Eggenberger, Harry, Strickler and Zangger, each of whom have appended their names to sections. The water-power still available can be reckoned at 8,000,000 of installed horse-power. In 1922 53 per cent. of the energy was used for lighting, motive power and heating, 23 per cent. for electro-chemical and metallurgical processes, 16 per cent was exported to foreign countries, and 8 per cent. was used for railways. It is estimated that 95 per cent. of all localities was connected to electric distribution systems, and 90 per cent. of the houses were fitted with electric light; 95 per cent. to 98 per cent. of the motors were electrical machines and from 40 per cent. to 45 per cent. of the railways were electrified. The price per unit was relatively high on account of the cost of transmission. The rivers had a small flow in winter and large in summer, and water was stored in lakes, &c., for equalisation. The rivers are mostly public property; concessions are usually granted by the Cantons, subject to compliance with Federal laws.

Spain.—Originally in Spain regulations regarding water were concerned only with the requirements for irrigation. Latterly attention has been paid also to power development, and concessions totalling 4,413,980 h.p. have been granted, large concessions being made in 1916 to 1920. Of the total only 1,261,118 h.p. are in operation and 2,160,610 under construction. The total available power is estimated at 6,000,000 h.p. Dams will be increasingly necessary for these resources to be utilised, for the regulation of the flow of the rivers, as already has been the case on the Tagus and the Noguera-Pallaresa. The greatest development has been in the Pyrenean zone, and the supplies are absorbed by Barcelona and the industries in its neighbourhood.

Austria.—In the Austrian Republic water-powers up to about 3·7 millions h.p. exist, based on low water discharges. At the end of 1923 about 220,000 h.p. had been developed and 65,000 h.p. were in hand, the present installations having plants of a maximum capacity of 582,000 h.p. The linking up of installations would result in more of the available production being utilised. High-tension transmission lines aggregate about 8,000 km., mostly for three-phase, 50-cycle current. Projected schemes aggregate about 2,285,000 h.p. Large outputs would be obtainable from the Danube where long side canals could be constructed. Barrages are not viewed favourably. The cost of work on this river would be high. Austria imports a certain quantity of coal, and by the development of water power it is hoped to reduce this. The coal resources of the country are placed at 400,000,000 tons. Of these 96 per cent. are lignites and brown coals, 4 per cent. being bituminous. The production is about 3·3 million tons per annum, most of which is brown coal. For bituminous coal the country will continue to be dependent upon foreign sources.

Hungary—The dismemberment of Hungary greatly reduced that country's power resources, and it now possesses little water power. The natural gas and naptha region were lost under the Peace Treaty. Coal and peat constitute the chief resources, the reserves of the former amounting to 119 million tons of bituminous coal, 430 million tons of brown coal and 500 million tons of lignite. Peat lands extend to about 200,000 acres.

Czechoslovakia.—This country possesses reserves of coal to the estimated extent of 8,787 million tons, and of lignite 12,434 million tons. In 1921 the output was 9,361,220 tons of black coal and 18,753,585 tons of lignite. Oil has to be imported to meet the country's requirements. Since the war the development of water power has been seriously undertaken and the State is investigating the resources in this direction. The total available is now estimated at 1,722,000 horse-power, but of this only 155,000 horse-power are utilised. The development can only advance as industry extends. The sources of energy are distributed conveniently, localities lacking in coal having abundant water power. For this reason numbers of small private generating systems exist, with, however, the disadvantages of lack of uniformity as regards current, &c. Centralisation is aimed at, with stations at the coal fields, for parts of the country where steam generation is necessary.

Denmark.—Denmark is unfavourably placed as regards water-power, but the subject became of importance during the Great War, and plans were drawn up for several hydro-electric stations, some of which are now working while others are under construction. The requirements of Jutland are now met by existing hydro-electric and steam stations so that the ultimate utilisation of all the water power is at present doubtful.

Norway.—Norway is one of the countries specially favoured as regards water power. The majority of the rivers include large and small lakes which can be made use of for regulation. Precipitation is mostly in the form of snow and there are regular annual periods of low and high flow. Low flow extends over a long period making regularisation essential. Four reports were submitted for this country, one dealing with the hydrography of the country, a second with the water power resources, a third with the effect of the latter on the country and on international affairs, and the fourth on the coalfields of Spitsbergen. The report on water power resources was by Mr. I. Kristensen who places the total resources at 12·2 million horse-power, of which only 1·2 millions are at present utilised. The peculiar features of Norwegain water power embrace the facility of regularisation by the lakes, above referred to; the concentration of large powers at comparatively few sites; the prevalence of solid rock, and the fact that more than half the resources are available in the immediate vicinity of the sea-bord, and navigable waters. Twenty-nine stations, each developing more than 30,000 horse-power produce a total of 950,000 horse-power. One station develops no less than 235,000 horse-power. The possibilities of further development depends first on electric heating of houses, the electrification of railways and small industries; secondly, on the establishment and development of large industries requiring cheap transport and a cheap supply of electricity; and thirdly, on the export of power. The latter may quite likely become an important international factor in Northern Europe. The report by Mr. S. Kloumann is a development of this point. The author points out that Norway is without exception *the* country of cheap hydro-electric power, which, unlike coal or oil resources, is inexhaustible. The western coast is richest in possibilities and is especially adapted to electro-chemical processes, while the east and southern sections are convenient for public distribution and for exportation. However, it would be possible to transmit supplies to some extent from the western to the other districts.

The report on the coal resources of Spitzbergen and Bear Island by Mr. Adolf Hoel puts the total resources of Spitzbergen at little short of 13,000 million tons of qualities ranging 11,470 B.Th.U. up to about 14,461 B.Th.U. The resources of Bear Island are placed at 200 million tons of rather lower average, *i.e.*, between 11,426 B.Th.U. and 13,732, most of the samples being on the lower side. Mining is easy on account of the small dip of the seams, and the frozen ground, and the absence of gas and water, so that the production per man employed is high.

Sweden.—Sweden possesses no coal fields. and water power is one of its chief assets. Of 1,950,000 turbine h.p. developed in 1923 1,400,000 were developed by means of hydraulic turbines. The total water resources are placed at 11,600,000 h.p., although at present the amount capable of practical and economical development appears to be in the neighbourhood of 8·8 millions h.p. 30 per cent. of the hydraulic resources of the country and 28 per cent. of the power produced now in hydro-electric stations belongs to the State. The State has no monopoly in this matter and co-operates with private concerns in a perfectly loyal manner. Schemes for districts are investigated by a State Commission. The country possesses immense forests, practically unexploited as a source of fuel except for domestic purposes and for the manufacture of charcoal for metallurgical purposes. There are bituminous schistes from which it has been shown to be possible to extract a useful oil, while peat deposits were utilised during the war for fuel for ordinary furnaces, and in powdered form for locomotives. In time of peace, however, this cannot compete with imported coal.

Finland.—The resources of Finland consist of waterfalls, wood and peat. None of these has been developed to any large extent, though water power amounting to 189,700 h.p. is utilised in 148 plants. Of the power developments in hand the State scheme at Imatra for some 168,000 h.p. is the most important. Surveys and gaugings being incomplete, an estimate for the whole country's water resources is impossible. Information is available pointing to definite possibilities amounting to 8,582,000 h.p. at periods of maximum flow, but only 1,314,000 available for nine months of the year, pointing to the need for regulation or supplementary steam stations. The rivers abound in lakes, between which are rapids or falls of low head. The fuel of Finland consists of wood only. The annual growth of timber is estimated at 44 million cubic metres and the consumption at 40 million cubic metres, of which 48 per cent. is used as fuel. The deposits of peat are estimated at 2,000 million tons of air-dried peat.

Esthonia.—Water power resources to the extent of about 170,000 h.p. are recorded for Esthonia in a short report by the Ministry of Trade and Industry of that country, of which about 16,953 h.p. are utilised, while 90,000 are embraced in a Government scheme on the Narowa River at two sites heads of 21 and 5 metres respectively. The country possesses valuable oil shales to an amount of probably 5,000 million tons. The oil shale deposits are worked both by the Government and by private companies. The shales are used as fuel and for the production of gas and oils. It is used as fuel in cement works, under boilers and on locomotives, for heating houses and for copper smelting. It is also exported to Finland and Latvia. The oil distilling industry is new. An experimental plant having proved successful, an installation capable of dealing with 200 tons daily is being put down and will be ready by 1924.

Russia.—Three reports submitted for Russia deal respectively with the country's resources in coal, oil shale and oil, the supplies of peat, and the programme of electrification. The report on coals, &c., places the resources at about 428,715 million tons, of which 88·36 per cent. is brown coal and only 8·79 per cent. anthracitic. The report discusses the deposits by districts, according to 21 sections, and the figures relate to visible supplies, probable supplies and possible supplies; the first two classes in the aggregate represent only a small fraction of the figure given above. The question of shales and of oil fields are discussed in a similar manner. Peat to the extent of 319,839,000 millions of cubic metres is supposed to exist in the country, the consumption amounting to about 2½

million tons per annum. It is expected that peat will play an important part in the development of electric power in Russia, as a result of recent work on the combustion of peat in large boilers. The water-power resources are large, the total horse-power available at sites giving over 10,000, amounting to 38,740,000, and for installations less than 10,000-h.p. about 23,640,000-h.p. of all of which only about 800,000-h.p. are at present utilised. The drawback to development lies in the fact that the largest resources are in districts unable to utilise them and their distances from centres requiring energy makes economical transmission impossible. A "State Commission of the Electrification of Russia" was formed in 1920 and recommended that electric power stations should be erected where hydraulic power could be used advantageously, or fuel used at the site instead of being transported long distances, where sufficient consumers were available. The plants were to be available later for the electrification of railways of agriculture and of municipal services. Thirty plants are proposed, the programme of construction extending over 10–15 years. At the present time seven plants are being erected, having a total capacity of 200,000 kw.

Siberia.—The author of the Siberian report on water power, remarks upon the complete lack of data available on the subject. As a result of calculations, however, Mr. S. Balakshin arrives at available power of not less than 51,138,000 h.p., of which only 0·178 per cent. is at present utilised. The Yenisei, it is estimated, could be utilised to the extent of probably over 27 million h.p., and the Amur for over 25 million. These figures are on a nine-months' basis. The author believes his report to be the first attempt at a general survey of the subject for this country.

China.—Data for China are very incomplete, but recent researches have made it possible to arrive at more exact knowledge on the country's resources. The attempted survey in the report presented by Messrs. T. Shing and W. H. Wong, emphasises the need for more thorough investigation. The anthracite fields in North Honan have reserves of about 800 million tons, and those of Shansi about 2,370 million tons. Bituminous coal is widely distributed; lignite is in use from one mine at present; peat has not been exploited though it exists in several provinces. The reserves of coal are put at no less than 23,435 million tons. Petroleum is known to occur in large fields, but at present is undeveloped. Water power is available in the upper reaches of rivers, but surveys have not yet been made in this connection.

Japan.—The authorities in Japan took up the question of water power surveys in 1910, since which date a great deal of information has been collected. Some 2,822 suitable sites still remain to be developed, capable of giving at low flow about 6,415,000 h.p. At present 615 sites have been developed, yielding 1,694,493 h.p., while at 182 further points 1,357,600 h.p. of plant is in course of construction.

Dutch East Indies.—The two reports are presented for the Dutch East Indies, one on water power and one on fuel. The former gives the available water power based on nine months minimum at 8,800,000, Sumatra and Dutch Borneo each contributing about 3,000,000 and the balance is divided almost equally between Java and the Celebes. The sites definitely investigated represent 1,560,000 h.p., in addition to 80,500 h.p. at sites already developed. The annual production of crude oils amounts to over 2 million tons. The State has a departmental "Service of Water Power and Electricity," forming part of the Department of Industries, and this has charge of surveys, registration and control of water power, electrical transmission, state projects and constructions, and the study of water reservations, &c. The fuels used consist of coal, bagasse, wood, liquid fuels of various characters, and natural and producer gas. The Dutch East Indies possess both bituminous and anthracite coals, but most of the coals are very friable with a high percentage of moisture, highly gaseous and non-coking, requiring special furnace construction. It is probable that the use of powdered fuel will develop in consequence. The report on fuels contains results obtained in the islands with fuels of various local kinds, including coal, wood, bagasse, oil, benzine, and gas.

HANDBOOK FOR OXY-ACETYLENE WELDERS.—A copy of a practical handbook on the welding and cutting of metals by means of the oxy-acetylene blowpipe, has been prepared by Mr. Leonard M. Fox, general manager of Messrs. Allen-Liversidge, Limited, Victoria Station House, Westminster, S.W.1, and is obtainable from that firm at the price of 1*s.* 6*d.* A particularly useful feature of the book is the inclusion of a coloured plate showing the appearance of the flame with correct and incorrect proportions of oxygen and acetylene, and also with the gases correctly proportioned for heating and cutting work. Air-acetylene flames for brazing, soldering, lead burning, paint burning, &c., are also illustrated in the same way. The explanatory matter is clear and concise and is written in language which an ordinary welder will have no difficulty in understanding.

CATALOGUES.

Maps.—A 24-page catalogue of specimen parts of maps, with some notes on the various processes involved in map-making, is to hand from Messrs. George Philip and Son, Limited, 32, Fleet-street, London, E.C.

Roller Bearings.—Messrs. Hyatt, Limited, 56, Victoria-street, London, S.W.1, have sent us a folder describing the application of their roller bearings to light and heavy rolling stock, hoisting machinery, trucks, trollies and conveyors.

Coal-Dust Firing.—The Underfeed Stoker Company, Limited, Aldwych House, Aldwych, London, W.C., have issued a catalogue of the Lopulco plant for pulverising, conveying and feeding coal dust fuel for boiler firing. The whole subject is very exhaustively discussed.

Electrical Machinery.—A particularly interesting pamphlet describing and illustrating the auxiliary electrical machinery and pumping plant supplied for the new Barton power station of the City of Manchester by Messrs Mather and Platt, Limited, Manchester has been received from that firm.

Automatic Controllers for Pumps.—A catalogue describing their automatic controllers for pumps is to hand from Messrs. Electric Control, Limited, Bridgeton, Glasgow. An example dealt with is an installation for four multi-stage, high-pressure turbine pumps for supplying accumulators for hydraulic power service at docks.

Electric Controls.—The English Electric Company, Limited, Queen's House, Kingsway, London, W.C., have sent us a catalogue of their camshaft control apparatus for motor coach trains, explaining the construction and operation of the system with illustrations of details and of complete applications to railway coaches.

Weighing Machines.—Messrs. Samuel Denison and Sons, Limited, Hunslet, Leeds, have sent us a copy of their periodical "The Denison Weigh," which contains some interesting historical matter on the subject of weighing customs and legislation, as well as a general description of the firm's weighbridges and works.

Electrical Instruments.—Messrs. Johnson and Phillips, Limited, Charlton, London, S.E.7, have issued a new catalogue of electrical instruments made by them and including ammeters and voltmeters of the moving-iron, hot-wire, and moving-coil types and also long-scale induction instruments and shuntless hot-strip ammeters.

Safety Devices.—Mr. C. L. Stokoe, Laburnham-avenue, Wallsend-on-Tyne, has sent us a series of cards illustrating the safety devices for circulating systems described on page 584 of our 115th volume. An oil-pressure alarm for the forced-lubrication systems of high-speed engines, air compressors, &c., is also dealt with.

Electric Resistances.—The Rheostatic Company, Limited, Slough, Bucks, have issued a catalogue describing the method (Satchwell's Patent) of forming resistance grids so as to obtain rigidity in the assembled units and illustrating some of the resistances supplied by the firm for cranes, furnace chargers, welding plants, tramway cars and electric locomotives.

Stratified Coal Fuel.—A press and other plant for making small coal into blocks is to hand from Messrs. Macnab Stratified Coal, Limited, 119, Victoria-street, London, S.W. 1. The process is a patented one, in which an oscillating motion is applied under slight pressure and has the effect of closely consolidating the material and arranging it in strata. Considerable advantages in manufacture and use are claimed for the process.

Oil Engines.—Messrs. Sulzer Brothers, 31, Bedford-square, London, W.C.1, have sent us a copy of a new catalogue of oil engines of from 20 to 200 brake horse-power. The engines are of the two-cycle type with positive fuel injection and employ a compression pressure of over 450 lbs. per square inch. They are built in three types for stationary work, auxiliary marine service, and marine propulsion, the last mentioned type being fitted with reversing gear.

Steam Plant.—A series of leaf catalogues specially prepared for the British Empire Exhibition has reached us from Messrs. Cole, Marchent and Morley Limited, Wakefield-road, Bradford. These catalogues deal with central-exhaust engines, compound engines specially designed for the economical extraction of heating steam, surface and jet condensing plant, as well as with accessory machinery, oil engines, and various new products of the firm, including vacuum drying plants, gilled air filter-coolers, closed circuit air coolers, and refrigerating plant.

Decorative Lighting.—The use of coloured lamps and of white-light projectors for decorative illumination is dealt with in a special catalogue received from the General Electric Company, Limited, Kingsway, London, W.C. 2. The brackets and projector lamps for lighting the external surfaces of buildings and the internal ceilings and walls are fully described. Colour effects are obtained with lamps coated with a thin hard layer of coloured china, which is durable and washable, and can be supplied in white, red, orange, yellow, green, blue and flame colours.

Weighbridges.—Messrs. Henry Pooley and Son, Limited, John Bright-street, Birmingham, have issued a new edition of their catalogue of weighbridges. The forms suitable for weighing vehicles, other than carts and lorries for which the machines were originated, continues to increase, and in addition to those for weighing cattle and ordinary railway wagons, there are now types suitable for aeroplanes, motor cars, tramway cars, and railway wagons of great length. A considerable part of the space in the catalogue is devoted to locomotive weighing machines indicating the weight on each wheel.

Electric Locomotives.—Much information on the subject of the development of the electric locomotive is given in a publication issued by the Baldwin & Westinghouse firms of the United States. A section by Mr. Paul T. Warner gives particulars of electric-locomotives supplied for service on the trunk lines of the United States, with descriptions of the conditions of work for which they were designed, while Mr. Howard R. Barnes gives similar information on those supplied for South America and Japan. The publication has reached us from the Westinghouse Electric International Company, 2, Norfolk-street, Strand, London, W.C.

Pumps.—The new edition of their catalogue of pumps issued by Messrs. A. G. Mumford, Limited, Colchester, will be found of considerable interest to engineers. These pumps are made in a large variety of forms specially suitable for specific conditions of working and arranged for steam, electric motor and belt drives. The list includes boiler feed, auxiliary feed, air and circulating condenser pumps; oil fuel transfer and cargo oil pumps; bilge, ballast and fire pumps; heavy ram pumps for high pressures; a condenser with combined air and circulating pumps; a portable vertical boiler with pumping set; special pumps for sugar factories; and a three-throw hand pump for lighting up the first of a group of oil-fired boilers.

Toothed Gears.—A catalogue containing a large number of illustrations of toothed gears has come to hand from the Power Plant Company, Limited, West Drayton, Middlesex. The illustrations include tramway gears; single, double and triple helical bevel sets; staggered and continuous double helical reduction gears; a large number of gears with housings for marine propulsion, mining, pumping and industrial machinery, including colliery winding and rolling mill drives; change-speed gear-boxes for machine tool drives; and turbo-generator gears. Some illustrations of the ships on which the firm's reduction gears have been installed, including H.M.SS. Queen Elizabeth and Malaya and the R.M.S. Aramis, are also given in the catalogue.

Asbestos Goods and Engineers' Supplies.—An exceptionally comprehensive catalogue of asbestos goods and engineers' supplies has recently been issued by Bell's United Asbestos Company, Limited, Southwark-street, S.E.1, in the form of a well-printed and strongly bound volume containing upwards of 450 pages, which are very fully illustrated. Reference to the various sections, numbering 12 in all, is facilitated by the provision of thumb tabs, and the first section gives full particulars of asbestos goods such as millboard, paper, fabrics and yarns, packings for all purposes, jointing materials, non-conducting coverings for boilers, steam pipes, cold stores, &c.; lubricating oils and greases are also dealt with in this section. In the next section, particulars are given of various brake-lining materials, one of which is known as Raybestos and is made in the form of rolls of different widths and thicknesses. This material consists of an impregnated and compressed asbestos fabric in which fine brass wires are interwoven. The same section deals with rubber goods; flexible metallic tubing; balata, leather, and rubber belting; belt fasteners, &c., while later sections cover most of the ordinary engineer's requirements for power-transmission accessories, such as pulleys, shafting, plummer blocks; &c., lubricators; fittings for steam, water and gas; sundries; machine and small tools; pumps; steam engines and boilers; lifting appliances, &c. Among the steam fittings we noticed a stop valve sold under the trade name "Victor," and specially designed for use with high-pressure and superheated steam. The valve and seating are made of a chrome alloy and the seating is reversible. An external screw is employed to operate the valve, and a novel method of raising the gland for the purpose of re-packing the stuffing box is provided. These valves are suitable for steam pressures up to 300 lb. per square inch. The remainder of the catalogue is devoted to building materials containing asbestos, such as "Poilite" and "Everite" tiles, flat and corrugated sheeting for roofing, and "Decolite" composition for floors, and, in conclusion, a number of useful tables of data and a complete general index to the contents are given. The fact that prices are mentioned in all cases adds considerably to the utility of the catalogue, which is in every respect a highly creditable production.

VERY FINE METALLIC FILAMENTS.—A method of drawing very fine wires, somewhat similar to Wollaston's for preparing very thin platinum wires, is described by G. F. Taylor, of the Bureau of Plant Industry, Washington, in the May issue of the *Physical Review*. Taylor drops a piece of the metal into a glass or quartz tube about 2 mm. in diameter, closed below, melts the metal, squeezes off the oxide film on the surface of the metal and draws out the portion containing the metal in a furnace almost to any desired length. He thus obtains very fine glass capillaries containing a minute metal filament. Taylor has been able to prepare filaments of lead, antimony, bismuth, gold, silver, copper, iron, tin, cadmium, &c. The glass or quartz can be dissolved off subsequently by means of hydrofluoric acid which does not attack the metals mentioned. The wires are said to be bright metallic, of high mechanical strength and of a constant temperature coefficient of electric resistance. For some uses, the glass sheath is quite convenient, as when the filaments are to be used for the suspension of moving coils, or as rheostats or as hair lines in telescopes. The thin filaments of bismuth and antimony are found to be of high tensile strength and quite pliable, and are thus very suitable for making thermocouples.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

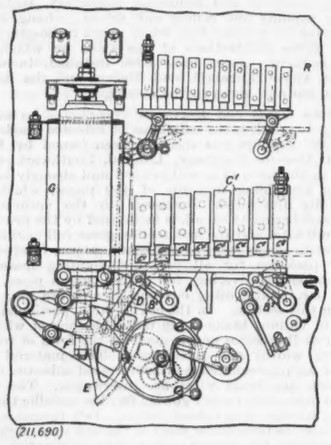
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

211,690. Brookhirst Switchgear, Limited, Chester, and A. C. Livesey, Chester. Automatically-Operated Electric Motor Starters and Controllers. (3 *Figs.*) February 13, 1923.—The invention relates to automatically-operated motor starters and controllers of that type in which the resistance is cut out by movement between a bar and a series of yielding contacts so arranged that movement imparted to the bar by electro-magnetic means brings the surface of the bar into pressure contact with the yielding contacts in succession, the bar in its final "on" position making pressure contact with all the yielding contacts. According to the invention, the contact bar is mounted on equal and parallel radius links and the contact blocks are arranged so that their contact faces are parallel with the contact bar and are in stepped relationship, so that the bar comes into contact with them in succession. A is the contact bar mounted in the forked ends of the radius links B1 and B2 pivotally mounted on the insulating base-plate R. The link B1 is connected by the



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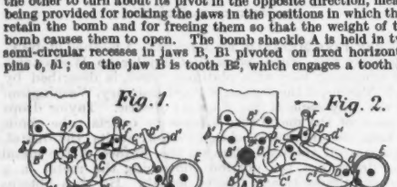
link D to the operating lever E pivoted to a base bracket F; The lever E1 is linked to the core of the solenoid G. When the solenoid is energised, say by completing its circuit by closing a press button, the bar A is moved at a controllable speed from its position shown in full lines into the position shown in dotted lines, the contact surface being maintained throughout the movement parallel to a fixed plane. The contacts with which the bar co-acts are a series of carbon blocks C1—C8 carried in spring boxes C1 fixed to the base R, the movement of the blocks in the boxes being in a direction normal to the plane of the contact face of the bar A, the contact faces of the several blocks being parallel with the contact face, and the springs tending to move the blocks towards the contact bar; the movement of each block in this direction is, however, limited by a stop, and the limit stops are so disposed that the contact faces of the blocks, when they are clear of the bar, take up a stepped position as shown. (*Accepted March* 5, 1924.)

GUNS AND EXPLOSIVES.

212,036. H. W. Holland, London, and W. Mansfield, London. Bomb Release Mechanism. (2 *Figs.*) January 17, 1923.—The invention relates to mechanism for dropping bombs from aircraft. According to the invention, a bomb is supported by two jaws which are pivoted on horizontal axes and are so constructed that when one is turned about its pivot, it compels the other to turn about its pivot in the opposite direction, means being provided for locking the jaws in the positions in which they retain the bomb and for freeing them so that the weight of the bomb causes them to open. The bomb shackle A is held in two semi-circular recesses in jaws B, B1 pivoted on fixed horizontal pins *b*, *b*1; on the jaw B is tooth B2, which engages a tooth B3



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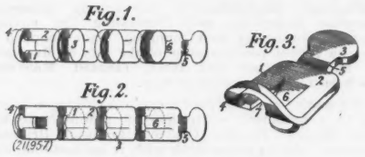
formed on the jaw B1 in such a way that when the jaw B is moved in either direction about its pivot *b* it forces the jaw B1 to move in the opposite direction about its pivot *b*1. When the shackle has been introduced between the jaws they are brought into the positions shown in Fig. 2 and locked in those positions by a lever C mounted on a stud *c*. One arm C1 of this lever engages the jaw B; the other arm C2 lies between the two arms of a cocking piece D carried on a pivot *d* and provided with a handle *d*1. When this cocking piece is turned into the position shown in Fig. 2, a tail D1 upon it compresses a spring E and its nose D2 comes beneath a spring trigger F. As it is turned into this position the cocking piece acting upon the arm C2 turns the lever C into the position shown in Fig. 2. The jaws B, B1 are thus locked and the bomb is securely held. To release the bomb the trigger F is turned about its pivot *f* in the direction shown by the arrow (Fig. 2) so that it passes out of contact with the nose D2 of the piece D, whereupon the spring E turns the piece D clockwise, and the lower arm of the cocking piece therefore gives a violent blow to the arm C2, so that the lever C is turned sharply out of engagement with jaw B, whereupon the weight of the bomb causes the jaws to open and thus the bomb is released. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

211,957. Camp and Co., Limited, London, A. H. F. Perl, London, and R. H. Carter, London. Chains and Belts. (12 *Figs.*) November 29, 1922.—The invention relates to links for use in the manufacture of chains and belts, the links being of the one-piece type having one end of T-shaped form and a slot in the body of the link. Each link 1, of which the chain is composed, is formed in one piece. One end 2 is provided with a T-shaped projection 3 by means of which one link can be engaged with an adjacent link. In order to prevent the links from becoming automatically or accidentally disengaged from each



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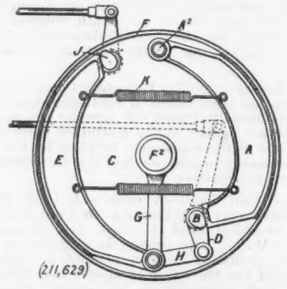
other, opposite ends of the links are curved to one side of the link, as shown at 4, 5 so that after the T-shaped projection has been engaged with an adjacent link the curvature of the ends of the link may prevent the links associated therewith becoming detached or disengaged. Each link 1 is provided with a tongue 6 and slot 7, the tongue 6 offering, when closed, a positive resistance to prevent the co-operating link from becoming disengaged. Each link may be stamped from a separate blank or from a strip of suitable material or from a sheet of metal of any desired size. (*Sealed.*)

MOTOR ROAD VEHICLES.

211,629. Sunbeam Motor Car Company, Limited, Wolverhampton, and L. Coatalen, Wolverhampton. Brakes. (1 *Fig.*) December 14, 1922.—The invention relates to vehicle brake mechanism of the kind in which there is employed a revolving drum engaged by a pair of shoes or blocks. According to the invention, the connection between the two shoes is through multiplying lever mechanism. In one method of carrying out the invention for an expanding brake as illustrated in side elevation, the shoe A forming the main brake is suspended from one end A2, and at the other end is acted upon by a cam B which is pivoted to an anchor-plate C, and is provided with a short arm D to effect its angular movements. The servo-brake is a single shoe E arranged inside the drum F opposite to the main brake



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shoe A, and is at one end supported by a radius rod G, angularly movable about the axis F2 of the brake drum. The end of the servo-brake shoe thus supported, is, by the agency of a link H, operatively connected to the arm D of the cam B, the disposition of the parts being such that when the servo-brake shoe E is applied to the drum F its circumferential movement due to the movement of the drum acts to apply the main brake A through the parts H and D. The servo-brake shoe E is acted upon by a cam J at the end remote from its suspension means, so as to bring it into engagement with the brake drum, and this cam may be actuated from the usual brake pedal. The two shoes may be connected to one another as usual by pull-off springs K, so that their arrangement in this respect broadly resembles that of an ordinary expanding brake. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

210,941. R. J. M. Inglis, Peebles. Securing Rails in their Chairs. (11 *Figs.*) December 27, 1922.—The invention has reference to means for securing railway rails in their chairs. According to the invention, railway rails are retained in position by securing them in chairs having an inclined or curved plane or wedge member secured thereto or formed integral therewith and arranged to co-act with a metal key of such shape that by the action of the fixed inclined or curved plane or wedge member it

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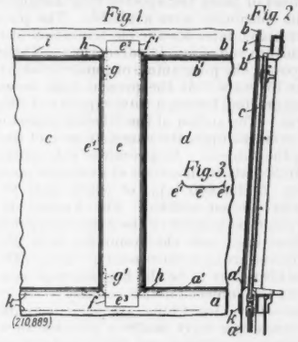
is expanded when driven home so as to secure firmly the rail in the chair. One of the jaws *b* has cast thereon a wedge member *f* formed of two oppositely tapered projections *h* and *h*1. The key *d* which co-operates with the wedge member *f* is shown in perspective in Fig. 3 and consists of a strip of steel shaped to form a slightly concave portion *i*, which bears against or lies adjacent to the web of the rail, then bent over as at *j* to conform approximately with the fishing angles of the rail and then bent over as at *k*, the edges thereof being rounded off to form the two bearing surfaces *l*, *l*. In use, the key is inserted between the rail and the jaw *b* so that the narrow end of the wedge member *f* enters the space formed between the two bearing surfaces *l*, *l*. The key is then driven home and is expanded by the wedge member to bear tightly against the rail and secure it in position. (*Sealed.*)

210,889. Cammell, Laird and Co., Limited, Sheffield, and A. S. Bailey, Sheffield. Metal Railway Vehicles. (7 *Figs.*) November 11, 1922.—The invention is to effect certain improvements in the manufacture of vehicles of metal, and particularly railway and tramway cars, so that certain parts, such as the sides or edges of windows and doorways, may have the appearance of having been produced in one piece by pressing, although actually jointed. The invention consists in the employment of panels, each having at least one inturned edge and severally shaped so that when assembled a projecting jointing portion fits a complementary jointing region, thereby enabling flush surfaces to be obtained if so desired. The joints thus formed may be completed, as by soldering, brazing or welding. In the construction shown, outside waist panels *a* are flanged or curved inwardly along their upper edges *a*1 to form the lower edges of window openings, and the cant-rail panels *b* are similarly



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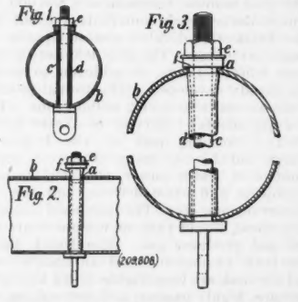
flanged or turned inwards along their lower edges *b*1 to form the top edges of such window openings. One window opening *c* is separated from an adjacent window opening *d* by a quarter-panel *e*, the vertical edges *e*1 of which are each flanged inwards to correspond with the upper and lower edges *a*1 and *b*1 of the window openings. The parts may, as shown, be united by blanking out the waist panel *a* and cant-rail *b* as shown at *f*, *f*1, respectively, and shaping the extremities *e*2, *e*3 of the quarter-panel *e* to agree therewith. The blanking out referred to may consist in the complete removal or mere displacement of the metal. The joint may be backed by means of knees *g*, *g*1 fitting snugly under the adjacent flanged or inturned portions *a*1, *b*1 and *e*1 of the panels *a*, *b*, *e* and riveted thereto, the joint proper *h*, or some part thereof, such as the edges exposed to view, being then soldered, brazed or welded. The remainder of the joint may, as shown, be masked by the customary mouldings *i* and *k*. (*Sealed.*)

MISCELLANEOUS.

209,808. The H. G. Hawker Engineering Company, Limited, Kingston-on-Thames, and B. Thomson, Kingston-on-Thames. Securing Bolts. (3 *Figs.*) October 14, 1922.—The invention relates to the securing of bolts through tubes of which the interior is inaccessible, or through plates of which one side only is accessible, and in general in any situation in which the bolt is to be positioned or associated with a distance piece of a length equal to the distance between the parts against which the bolt head and nut are to abut when the bolt is secured in position but which cannot conveniently be held during the operation of bolting up. In carrying the invention into effect in its application in a situation where it is required to pass a bolt transversely



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through a tube and to prevent distortion of the tube to any appreciable extent by means of a distance piece surrounding the bolt, one of the apertures (such as *a*) in the tube *b* through which the bolt *c* is to be passed is made sufficiently large to permit of a tubular distance piece *d* to be passed therethrough also, such distance piece being meanwhile located by reason of its surrounding the bolt. The latter is secured in position by the usual nut *e*, and during the operation of screwing up the nut the latter forces a coned washer *f* into the end of the tubular distance piece (as shown in Fig. 2), thus expanding the latter (as shown in Fig. 3) in such a manner as to locate the distance piece and prevent its withdrawal through the aperture by means of which it was entered into the tube.—(*Sealed.*)

"ENGINEERING NEWS-RECORD."—In commemoration of its fiftieth anniversary this year, *Engineering News-Record*, the well-known civil engineering journal, published in New York, has issued, in two sections, a special number giving interesting articles recording the progress made during the period throughout the world in the various branches of civil engineering. The articles are from the pen of well-known authorities and are admirably illustrated. Our American contemporary is to be congratulated upon a most successful achievement. We tender it many happy returns of its birthday.